



US010793551B2

(12) **United States Patent**
Ernst et al.

(10) **Patent No.:** **US 10,793,551 B2**
(45) **Date of Patent:** **Oct. 6, 2020**

(54) **BENZIMIDAZOLE-INDOLE INHIBITORS OF MNK1 AND MNK2**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **16/162,459**

(22) Filed: **Oct. 17, 2018**

(65) **Prior Publication Data**

US 2019/0119256 A1 Apr. 25, 2019

Related U.S. Application Data

(60) Provisional application No. 62/574,432, filed on Oct. 19, 2017.

(51) **Int. Cl.**

C07D 403/04 (2006.01)
C07D 401/14 (2006.01)
A61P 35/00 (2006.01)

(52) **U.S. Cl.**

CPC **C07D 403/04** (2013.01); **A61P 35/00** (2018.01); **C07D 401/14** (2013.01)

(58) **Field of Classification Search**

CPC C07D 403/04; C07D 401/14
USPC 514/256

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,223,505 A 6/1993 Hargreaves et al.
6,316,444 B1 11/2001 Hunt et al.
6,329,380 B1 12/2001 Goulet et al.
7,615,562 B2 * 11/2009 Bollbuck C07D 239/42
514/275
9,382,248 B2 7/2016 Reich et al.
2002/0028936 A1 3/2002 Sperl et al.
2005/0065145 A1 3/2005 Cao et al.
2005/0107374 A1 5/2005 Elbaum et al.
2006/0270686 A1 11/2006 Kelly et al.
2007/0093502 A1 4/2007 Bonfanti et al.
2007/0099920 A1 5/2007 Binch et al.
2008/0146571 A1 6/2008 Augeri et al.
2008/0207613 A1 8/2008 Styles et al.
2008/0280891 A1 11/2008 Kelly et al.
2009/0042884 A1 2/2009 McDonald et al.
2010/0261743 A1 10/2010 Londregan et al.
2010/0286135 A1 11/2010 Reddy et al.
2011/0118455 A1 5/2011 Fujihara

(Continued)

FOREIGN PATENT DOCUMENTS

EP 0385850 A2 9/1990
EP 0431421 A2 6/1991

(Continued)

OTHER PUBLICATIONS

<Onicek et al. (2011) "Therapeutic inhibition of MAP kinase interacting kinase blocks eukaryotic initiation factor 4E phosphorylation and suppresses outgrowth of experimental lung metastases", *Cancer research*. 71(5):1849-1857.

Rowlett et al. (2008) "MNK kinases regulate multiple TLR pathways and innate proinflammatory cytokines in macrophages", *American Journal of Physiology-Gastrointestinal and Liver Physiology*. 294(2):G452-G459.

Tschopp et al. (2000) "Phosphorylation of eIF-4E on Ser 209 in response to mitogenic and inflammatory stimuli is faithfully detected by specific antibodies", *Molecular Cell Biology Research Communications*. 3(4):205-211.

(Continued)

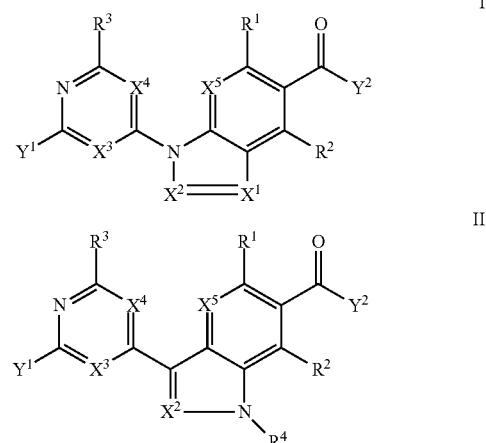
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(57)

ABSTRACT

The present invention provides synthesis, pharmaceutically acceptable formulations and uses of compounds in accordance with Formula I or Formula II, or a stereoisomer, tautomer or pharmaceutically acceptable salt thereof.



For Formula I compounds X^1 , X^2 , X^3 , X^4 , X^5 , Y^1 , Y^2 , R^1 , R^2 , R^3 , R^4 , R^5 , R^6 , R^7 , R^8 , R^9 , R^{10} , R^{11} , R^{12} and R^{13} are as defined in the specification. The inventive Formula I and Formula II compounds are inhibitors of MnK and find utility in any number of therapeutic applications, including but not limited to treatment of inflammation and various cancers.

(56)

References Cited

U.S. PATENT DOCUMENTS

2012/0028963 A1 2/2012 Lee et al.
2012/0165334 A1 6/2012 Boezio et al.
2012/0214994 A1 8/2012 Chi et al.
2013/0245000 A1 9/2013 Thotapally et al.
2013/0303585 A1 11/2013 Dunman et al.
2014/0179689 A1 6/2014 Lawrence et al.
2015/0141407 A1 5/2015 Xie et al.
2015/0197511 A1 7/2015 Zhang et al.
2016/0122323 A1 5/2016 Gray et al.
2016/0214978 A1 7/2016 Du et al.
2016/0237095 A1 8/2016 Kim et al.
2016/0316751 A1 11/2016 Köhler et al.
2016/0355503 A1 12/2016 Zhou et al.
2017/0057942 A1 3/2017 Tafesse et al.
2017/0112832 A1 4/2017 Zanin-Zhorov et al.
2017/0121346 A1 5/2017 Sprengeler et al.

FOREIGN PATENT DOCUMENTS

EP 0515942 A1 12/1992
WO 9744326 A1 11/1997
WO 2007121662 A1 11/2007
WO 2010020432 A2 2/2010
WO 2010110686 A1 9/2010
WO 2015069752 A1 5/2015
WO 2016172010 A1 10/2016
WO 2017075367 A1 5/2017
WO 2017075394 A1 5/2017

OTHER PUBLICATIONS

International Search Report with Written Opinion corresponding to International Patent Application No. PCT/US2018/056183, dated Jan. 22, 2019, 10 pages.

* cited by examiner

BENZIMIDAZOLE-INDOLE INHIBITORS OF MNK1 AND MNK2

CROSS-REFERENCE TO RELATED PATENT APPLICATIONS

The present application claims the benefit of U.S. provisional application No. 62/574,432, filed Oct. 19, 2017, which is herein incorporated by reference.

FIELD

The present invention generally relates to compounds having activity as inhibitors of MAP kinase-interacting kinase (Mnk), for example Mnk1 and Mnk2, as well as to related compositions and methods for utilizing the inventive compounds as therapeutic agents for treatment of Mnk dependent diseases, including the treatment of cancer.

BACKGROUND

Eukaryotic initiation factor 4E (eIF4E) is a general translation factor but it has the potential to enhance preferentially the translation of messenger RNAs (mRNAs) that lead to production of malignancy-associated proteins. This selectivity may relate to an increased requirement for eIF4E and its binding partners for the translation of mRNAs containing extensive secondary structure in their 5'-untranslated regions (5'-UTRs). These mRNAs include those encoding certain proteins that control cell cycle progression and tumorigenesis. Under normal cellular conditions the translation of these malignancy-associated mRNAs is suppressed as the availability of active eIF4E is limited; however, their levels can increase when eIF4E is over-expressed or hyperactivated. Elevated levels of eIF4E have been found in many types of tumors and cancer cell lines including cancers of the colon, breast, bladder, lung, prostate, gastrointestinal tract, head and neck, Hodgkin's lymphomas and neuroblastomas.

Initiation of cap-dependent translation is thought to depend on the assembly of eIF4F, an initiation factor complex including eIF4E, the scaffold protein eIF4G, and the RNA helicase eIF4A. Because eIF4E is the only one of these proteins that binds directly to the mRNA cap structure, it is the key factor for the assembly of eIF4F at the 5' cap. The scaffold protein, eIF4G, also recruits the 40S ribosomal subunit to the mRNA via its interaction with eIF3 and binds eIF4B, a protein that aids the RNA-helicase function of eIF4A, thus facilitating the translation of mRNAs that contain structured 5'-UTRs. The availability of eIF4E as part of the eIF4F complex is a limiting factor in controlling the rate of translation and therefore eIF4E is an important regulator of mRNA translation.

Regulation of eIF4E activity forms a node of convergence of the PI3K/Akt/mTOR and Ras/Raf/MAPK signaling pathways. The PI3K (phosphoinositide 3-kinase)/PTEN (phosphatase and tensin homologue deleted on chromosome ten)/Akt/mTOR (mammalian target of rapamycin) pathway is often involved in tumorigenesis and in sensitivity and resistance to cancer therapy. Deregulated signaling through the PI3K/PTEN/Akt/mTOR pathway is often the result of genetic alterations in critical components of this pathway and/or mutations at upstream growth factor receptors or signaling components. PI3K initiates a cascade of events when activated by, for example, extracellular growth factors, mitogens, cytokines and/or receptors, PDK1 activates Akt, which in turn phosphorylates and inactivates the tumor suppressor complex comprising TSC 1 and 2 (tuberous

sclerosis complex 1/2), resulting in the activation of mTORC1 (target of rapamycin complex 1) by Rheb-GTP. Activation of PDK1 and Akt by PI3Ks is negatively regulated by PTEN.

PTEN is a critical tumor suppressor gene and is often mutated or silenced in human cancers. Its loss results in activation of Akt and increases downstream mTORC1 signaling. The involvement of mTOR complex1 (mTORC1) in neoplastic transformation appears to depend on its regulatory role toward the eIF4F complex; overexpression of eIF4E can confer resistance to rapamycin. mTORC1 regulates the eIF4F complex assembly that is critical for the translation of mRNAs associated with cell growth, prevention of apoptosis and transformation. mTORC1 achieves this by phosphorylation and inactivation of 4E-BPs and the subsequent dissociation of 4E-BPs from eIF4E. This then enables eIF4E to interact with the scaffold protein eIF4G, permitting assembly of the eIF4F complex for the translation of structured mRNAs. mTORC1 also promotes activation of the translational activator, S6K, which phosphorylates the ribosomal protein S6 and other substrates, including eIF4B. mTORC1 signaling is inhibited by rapamycin and its analogues (rapalogs), although these compounds act allosterically, rather than directly inhibiting mTOR kinase activity.

Given the importance of the PI3K/Akt/mTOR pathway in regulating mRNA translation of genes that encode for oncogenic proteins and activated mTORC1 signaling in a high proportion of cancers, these kinases have been actively pursued as oncology drug targets. A number of pharmacological inhibitors have been identified, some of which have reached advanced clinical stages. However, it has recently become clear that the mTOR pathway participates in a complicated feedback loop that can impair activation of Akt. It has been shown that prolonged treatment of cancer cells or patients with mTOR inhibitors causes elevated PI3K activity that leads to phosphorylation of Akt and eIF4E, and promotes cancer cell survival. eIF4E, acting downstream of Akt and mTOR, recapitulates Akt's action in tumorigenesis and drug resistance, and Akt signaling via eIF4E is an important mechanism of oncogenesis and drug resistance *in vivo*.

In addition to the PI3K/Akt/mTOR pathway, eIF4E is also the target of the Ras/Raf/MAP signaling cascade which is activated by growth factors and for the stress-activated p38 MAP kinase pathway. Erk1/2 and p38 then phosphorylate MAP kinase-interacting kinase 1 (Mnk1) and MAP kinase-interacting kinase 2 (Mnk2). The Erk pathway is also activated in many cancers, reflecting, for example, activating mutations in Ras (found in around 20% of tumors) or loss of function of the Ras GTPase-activator protein NF1. Mnk1 and Mnk2 are threonine/serine protein kinases and specifically phosphorylate serine 209 (Ser209) of eIF4E within the eIF4F complex, by virtue of the interaction between eIF4E and the Mnk, which serves to recruit Mnk to act on eIF4E. Mice with mutated eIF4E, in which Ser209 is replaced by alanine, shows no eIF4E phosphorylation and significantly attenuated tumor growth. Significantly, while Mnk activity is necessary for eIF4E-mediated oncogenic transformation, it is dispensable for normal development. Pharmacologically inhibiting Mnk thus presents an attractive therapeutic strategy for cancer.

Despite increased understanding of Mnk structure and function, little progress has been made with regard to the discovery of pharmacological Mnk inhibitors and relatively few Mnk inhibitors have been reported: CGP052088 (Tschopp et al., *Mol Cell Biol Res Commun.* 3(4):205-211, 2000); CGP57380 (Rowlett et al., *Am J Physiol Gastrointest*

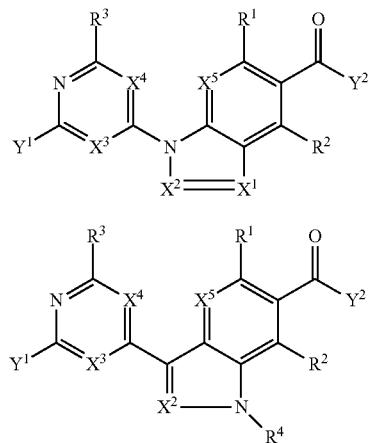
Liver Physiol. 294(2):G452-459, 2008); and Cercosporamide (Konicek et al., *Cancer Res.* 71(5): 1849-1857, 2011). These compounds, however, have mainly been used for the purpose of MnK target validation. More recently, investigators have proposed further compounds for treating diseases influenced by the inhibition of kinase activity of MnK1 and/or MnK2, including, for example, the compounds disclosed in International Patent Application no. WO/2017/075394 and U.S. Pat. No. 9,382,248.

Accordingly, while advances have been made in this field there remains a significant need in the art for compounds that specifically inhibit MnK kinase activity, particularly with regard to MnK's role in regulation of cancer pathways, as well as for associated composition and methods. The present invention fulfills this need and provides further related advantages.

SUMMARY

The present invention is directed to compounds that inhibit or modulate the activity of MnK, as well as stereoisomers, tautomers and pharmaceutically acceptable salts of such compounds. The present invention also is directed to pharmaceutically acceptable compositions containing such compounds and associated methods for treating conditions that would benefit from MnK inhibition, such as cancer.

In one embodiment the invention is directed to compounds according to Formula I or Formula II as well as to a stereoisomer, tautomer or pharmaceutically acceptable salt of such compounds,



wherein

X¹ is N or CR⁵;

X² is N or CR⁶;

X³ is N or CR⁷;

X⁴ and X⁵ are independently N or CR⁸;

Y¹ is H or NR⁹R¹⁰;

Y² is NR¹¹R¹², alkyl, cycloalkyl, heterocyclyl, aryl or heteroaryl;

R¹ is —OH, —SH, —CN, halogen, —(C₁-C₈)alkyl, —(C₂-C₈)alkenyl, —(C₂-C₈)alkynyl, —(C₁-C₈)haloalkyl, —O(C₁-C₈)alkyl, —O(C₁-C₈)haloalkyl, —O(C₁-C₈)alkyleneNHR⁹, —O(C₁-C₈)alkyleneY¹, —(C₁-C₈)alkyleneNHR⁹, —(C₁-C₈)alkyleneY¹, cycloalkyl, heterocyclyl, heteroaryl, aryl, —SR¹³, —SO₂(C₁-C₈)alkyl, —SO₂Y¹, NHR⁹, Y¹ or NR⁹SO₂R¹³;

R² is —OH, —CN, halogen, —(C₁-C₈)alkyl, —(C₂-C₈)alkenyl, —(C₂-C₈)alkynyl, —(C₁-C₈)haloalkyl, —O(C₁-C₈)alkyl, —O(C₁-C₈)haloalkyl, —O(C₁-C₈)alkyleneNHR⁹, —O(C₁-C₈)alkyleneY¹, —C(O)NHR⁹, —C(O)Y¹, cycloalkyl, heterocyclyl, heteroaryl, aryl, —SR¹³, —SO₂(C₁-C₈)alkyl, —SO₂Y¹, NHR⁹, Y¹ or R² and Y² can combine to form a 5- or 6-membered cycloalkyl or heterocyclyl ring;

R³, R⁵, R⁶ and R⁷ are independently —OH, —CN, halogen, —(C₂-C₈)alkenyl, —(C₂-C₈)alkynyl, —(C₁-C₈)haloalkyl, —O(C₁-C₈)alkyl, —O(C₁-C₈)haloalkyl, —O(C₁-C₈)alkyleneNHR⁹, —O(C₁-C₈)alkyleneY¹, —C(O)NHR⁹, —C(O)Y¹, —SR¹³, —SO₂(C₁-C₈)alkyl, —SO₂Y¹, NHR⁹, Y¹ or NR⁹SO₂R¹³;

R⁴ is —H, (C₁-C₈)alkyl, (C₁-C₈)haloalkyl, cycloalkyl, heterocyclyl, [(C₁-C₈)alkylene] heterocyclyl, aryl, [(C₁-C₈)alkylene]aryl or heteroaryl;

R⁸ is —OH, halogen, —CN, acetyl, —(C₁-C₈)alkyl, —S(C₁-C₈)alkyl, —(C₂-C₈)alkenyl, —(C₂-C₈)alkynyl,

—O(C₁-C₈)alkyl, —(C₁-C₈)haloalkyl, —O(C₁-C₈)haloalkyl, NHR⁹ or Y¹;

R⁹, R¹⁰, R¹¹ and R¹² are independently —H, —(C₁-C₈)alkyl, —(C₁-C₈)haloalkyl, —(C₂-C₈)alkenyl, —(C₂-C₈)alkynyl, —C(O)(C₁-C₈)alkyl, —C(O)cycloalkyl, —C(O)O(C₁-C₈)alkyl, —C(O)NH₂, —C(O)NH—NH₂, —C(O)NH—NH(C₁-C₈)alkyl, aryl, heteroaryl, heterocyclyl, or cycloalkyl, wherein R¹¹ and R¹² cannot both be —H;

R¹³ is —H, —(C₁-C₈)alkyl, —(C₁-C₈)haloalkyl, cycloalkyl, heterocyclyl, heteroaryl or aryl;

wherein any alkyl, cycloalkyl, heterocyclyl, heteroaryl or aryl is optionally substituted with 1, 2 or 3 groups selected from —OH, —CN, —SH, —S(O)NH₂, —S(O)NH₂, halogen, NH₂, NH(C₁-C₄)alkyl, N[(C₁-C₄)alkyl]₂, —C(O)NH₂, —COOH, —COOMe, —(C₁-C₈)alkyl, —O(C₁-C₈)alkyl,

—(C₂-C₈)alkenyl, —(C₂-C₈)alkynyl, haloalkyl, thioalkyl, cyanomethylene, NH₂—C(O)-alkylene-, NH₂—C(O)-alkylene-, NH(Me)C(O)-alkylene-, —CH₂—C(O)-lower alkyl, —C(O)-lower alkyl, cycloalkyl, —CH₂—C(O)-cycloalkyl, —C(O)-cycloalkyl, —CH₂—C(O)-aryl, —CH₂-aryl,

—C(O)-aryl, —CH₂—C(O)-heterocycloalkyl or heterocyclyl.

The present invention also provides a pharmaceutical composition comprising (i) a therapeutically effective amount of at least one compound according to Formula I or

Formula II, or a stereoisomer, a tautomer or a pharmaceutically acceptable salt thereof; (ii) in combination with a pharmaceutically acceptable carrier, diluent or excipient.

Also provided by the present invention is a method for attenuating or inhibiting the activity of MnK in at least one cell overexpressing MnK, comprising contacting the at least one cell with a compound according to claim 1 or a stereoisomer, tautomer or pharmaceutically acceptable salt thereof.

According to the inventive method at least one cell is a colon cancer cell, a gastric cancer cell, a thyroid cancer cell, a lung cancer cell, a leukemia cell, a B-cell lymphoma, a T-cell lymphoma, a hairy cell lymphoma, Hodgkin's lymphoma cell, non-Hodgkin's lymphoma cell, Burkitt's lymphoma cell, a pancreatic cancer cell, a melanoma cell, a multiple melanoma cell, a brain cancer cell, a CNS cancer cell, a renal cancer cell, a prostate cancer cell, an ovarian cancer cell, or a breast cancer cell.

According to yet another embodiment the invention provides a method for treating a MnK dependent condition in a mammal in need thereof, comprising administering to the mammal (i) a therapeutically effective amount of at least one compound according to claim 1 or a stereoisomer, tautomer

or pharmaceutically acceptable salt thereof, or (ii) a pharmaceutical composition in accordance with the invention.

Compounds and pharmaceutically acceptable formulations in accordance with the invention are useful for treating an MnK dependent condition such as colon cancer, gastric cancer, thyroid cancer, lung cancer, leukemia, B-cell lymphoma, T-cell lymphoma, hairy cell lymphoma, Hodgkin's lymphoma, non-Hodgkin's lymphoma, Burkitt's lymphoma, pancreatic cancer, melanoma, multiple melanoma, brain cancer, CNS cancer, renal cancer, prostate cancer, ovarian cancer or breast cancer.

The above embodiments and other aspects of the invention are readily apparent in the detailed description that follows. To this end, various references are set forth herein which describe in more detail certain background information, procedures, compounds and/or compositions, and are each hereby incorporated by reference in their entirety.

DETAILED DESCRIPTION

In the following description certain specific details are set forth in order to provide a thorough understanding of various embodiments of the invention. However, one skilled in the art will understand that the invention may be practiced without these details. Unless the context requires otherwise, throughout the present specification and claims, the word "comprise" and variations thereof, such as, "comprises" and "comprising" are to be construed in an open, inclusive sense (i.e., as "including, but not limited to").

Reference throughout this specification to "one embodiment" or "an embodiment" means that a particular feature, structure or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, the appearances of the phrases "in one embodiment" or "in an embodiment" in various places throughout this specification are not necessarily all referring to the same embodiment. Furthermore, the particular features, structures, or characteristics may be combined in any suitable manner in one or more embodiments.

Definitions

As used herein, and unless noted to the contrary, the following terms and phrases have the meaning noted below.

"Amino" refers to the $-\text{NH}_2$ substituent.

"Aminocarbonyl" refers to the $-\text{C}(\text{O})\text{NH}_2$ substituent.

"Carboxyl" refers to the $-\text{CO}_2\text{H}$ substituent.

"Carbonyl" refers to a $-\text{C}(\text{O})-$ or $-\text{C}(=\text{O})-$ group. Both notations are used interchangeably within the specification.

"Cyano" refers to the $-\text{C}\equiv\text{N}$ substituent.

"Cyanoalkylene" refers to the $-(\text{alkylene})\text{C}\equiv\text{N}$ substituent.

"Acetyl" refers to the $-\text{C}(\text{O})\text{CH}_3$ substituent.

"Hydroxy" or "hydroxyl" refers to the $-\text{OH}$ substituent.

"Hydroxyalkylene" refers to the $-(\text{alkylene})\text{OH}$ substituent.

"Oxo" refers to a $-\text{O}$ substituent.

"Thio" or "thiol" refer to a $-\text{SH}$ substituent.

"Alkyl" refers to a saturated, straight or branched hydrocarbon chain radical consisting solely of carbon and hydrogen atoms, having from one to twelve carbon atoms ($\text{C}_1\text{-C}_{12}$ alkyl), from one to eight carbon atoms ($\text{C}_1\text{-C}_8$ alkyl) or from one to six carbon atoms ($\text{C}_1\text{-C}_6$ alkyl), and which is attached to the rest of the molecule by a single bond. Exemplary alkyl groups include methyl, ethyl, n-propyl, 1-methylethyl (isopropyl), n-butyl, n-pentyl, 1,1-dimethylethyl (t-butyl), 3-methylhexyl, 2-methylhexyl, and the like.

"Lower alkyl" has the same meaning as alkyl defined above but having from one to four carbon atoms ($\text{C}_1\text{-C}_4$ alkyl).

"Alkenyl" refers to an unsaturated alkyl group having at least one double bond and from two to twelve carbon atoms ($\text{C}_2\text{-C}_{12}$ alkenyl), from two to eight carbon atoms ($\text{C}_2\text{-C}_8$ alkenyl) or from two to six carbon atoms ($\text{C}_2\text{-C}_6$ alkenyl), and which is attached to the rest of the molecule by a single bond, e.g., ethenyl, propenyl, butenyl, pentenyl, hexenyl, and the like.

"Alkynyl" refers to an unsaturated alkyl group having at least one triple bond and from two to twelve carbon atoms ($\text{C}_2\text{-C}_{12}$ alkynyl), from two to ten carbon atoms ($\text{C}_2\text{-C}_{10}$ alkynyl) from two to eight carbon atoms ($\text{C}_2\text{-C}_8$ alkynyl) or from two to six carbon atoms ($\text{C}_2\text{-C}_6$ alkynyl), and which is attached to the rest of the molecule by a single bond, e.g., ethynyl, propynyl, butynyl, pentynyl, hexynyl, and the like.

"Alkylene" or "alkylene chain" refers to a straight or branched divalent hydrocarbon (alkyl) chain linking the rest

20 of the molecule to a radical group, consisting solely of carbon and hydrogen, respectively. Alkynes can have from one to twelve carbon atoms, e.g., methylene, ethylene, propylene, n-butylene, and the like. The alkylene chain is attached to the rest of the molecule through a single or 25 double bond. The points of attachment of the alkylene chain to the rest of the molecule can be through one carbon or any two carbons within the chain. "Optionally substituted alkylene" refers to alkylene or substituted alkylene.

"Alkenylene" refers to divalent alkene. Examples of alk- 30 enylene include without limitation, ethenylene ($-\text{CH}=\text{CH}-$) and all stereoisomeric and conformational isomeric forms thereof. "Substituted alkenylene" refers to divalent substituted alkene. "Optionally substituted alk- 35 enylene" refers to alkenylene or substituted alkenylene.

"Alkynylene" refers to divalent alkyne. Examples of alkynylene include without limitation, ethynylene, propynylene. "Substituted alkynylene" refers to divalent substi- 40 tuted alkyne.

"Alkoxy" refers to a radical of the formula $-\text{OR}_a$ where 45 R_a is an alkyl having the indicated number of carbon atoms as defined above. Examples of alkoxy groups include without limitation $-\text{O-methyl}$ (methoxy), $-\text{O-ethyl}$ (ethoxy), $-\text{O-propyl}$ (propoxy), $-\text{O-isopropyl}$ (iso propoxy) and the like.

"Aryl" refers to a hydrocarbon ring system radical comprising hydrogen, 6 to 18 carbon atoms and at least one aromatic ring. Exemplary aryls are hydrocarbon ring system radical comprising hydrogen and 6 to 9 carbon atoms and at 50 least one aromatic ring; hydrocarbon ring system radical comprising hydrogen and 9 to 12 carbon atoms and at least one aromatic ring; hydrocarbon ring system radical comprising hydrogen and 12 to 15 carbon atoms and at least one aromatic ring; or hydrocarbon ring system radical comprising hydrogen and 15 to 18 carbon atoms and at least one aromatic ring. For purposes of this invention, the aryl radical may be a monocyclic, bicyclic, tricyclic or tetracyclic ring system, which may include fused or bridged ring systems. Aryl radicals include, but are not limited to, aryl radicals derived from aceanthrylene, acenaphthylene, acephenanthrylene, anthracene, azulene, benzene, chrysene, fluoranthene, fluorene, as-indacene, s-indacene, indane, indene, naphthalene, phenalene, phenanthrene, pleiadene, pyrene, and triphenylene. "Optionally substituted aryl" refers to an aryl group or a substituted aryl group.

"Cycloalkyl" refers to a stable non-aromatic monocyclic or polycyclic hydrocarbon radical consisting solely of carbon and hydrogen atoms, which may include fused or

bridged ring systems, having from three to fifteen carbon atoms, preferably having from three to ten carbon atoms, three to nine carbon atoms, three to eight carbon atoms, three to seven carbon atoms, three to six carbon atoms, three to five carbon atoms, a ring with four carbon atoms, or a ring with three carbon atoms. The cycloalkyl ring may be saturated or unsaturated and attached to the rest of the molecule by a single bond. Monocyclic radicals include, for example, cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, cycloheptyl, and cyclooctyl. Polycyclic radicals include, for example, adamantlyl, norbornyl, decalinyl, 7,7-dimethyl-bicyclo[2.2.1]heptanyl, and the like.

“Fused” refers to any ring structure described herein which is fused to an existing ring structure in the compounds of the invention. When the fused ring is a heterocyclyl ring or a heteroaryl ring, any carbon atom on the existing ring structure which becomes part of the fused heterocyclyl ring or the fused heteroaryl ring may be replaced with a nitrogen atom.

“Halo” or “halogen” refers to bromo (bromine), chloro (chlorine), fluoro (fluorine), or iodo (iodine).

“Haloalkyl” refers to an alkyl radical having the indicated number of carbon atoms, as defined herein, wherein one or more hydrogen atoms of the alkyl group are substituted with a halogen (halo radicals), as defined above. The halogen atoms can be the same or different. Exemplary haloalkyls are trifluoromethyl, difluoromethyl, trichloromethyl, 2,2,2-trifluoroethyl, 1,2-difluoroethyl, 3-bromo-2-fluoropropyl, 1,2-dibromoethyl, and the like.

“Heterocyclyl”, “heterocycle”, or “heterocyclic ring” refers to a stable 3- to 18-membered saturated or unsaturated radical which consists of two to twelve carbon atoms and from one to six heteroatoms, for example, one to five heteroatoms, one to four heteroatoms, one to three heteroatoms, or one to two heteroatoms selected from the group consisting of nitrogen, oxygen and sulfur. Exemplary heterocycles include without limitation stable 3-15 membered saturated or unsaturated radicals, stable 3-12 membered saturated or unsaturated radicals, stable 3-9 membered saturated or unsaturated radicals, stable 8-membered saturated or unsaturated radicals, stable 7-membered saturated or unsaturated radicals, stable 6-membered saturated or unsaturated radicals, or stable 5-membered saturated or unsaturated radicals.

Unless stated otherwise specifically in the specification, the heterocyclyl radical may be a monocyclic, bicyclic, tricyclic or tetracyclic ring system, which may include fused or bridged ring systems; and the nitrogen, carbon or sulfur atoms in the heterocyclyl radical may be optionally oxidized; the nitrogen atom may be optionally quaternized; and the heterocyclyl radical may be partially or fully saturated. Examples of non-aromatic heterocyclyl radicals include, but are not limited to, azetidinyl, dioxolanyl, thienyl[1,3]dithiinyl, decahydroisoquinolyl, imidazolinyl, imidazolidinyl, isothiazolidinyl, isoxazolidinyl, morpholinyl, octahydroindolyl, octahydroisoindolyl, 2-oxopiperazinyl, 2-oxopiperidinyl, 2-oxopyrrolidinyl, oxazolidinyl, piperidinyl, piperazinyl, 4-piperidonyl, pyrrolidinyl, pyrazolidinyl, quinuclidinyl, thiazolidinyl, tetrahydrofuryl, thietanyl, trithianyl, tetrahydropyranyl, thiomorpholinyl, thiamorpholinyl, 1-oxo-thiomorpholinyl, and 1,1-dioxo-thiomorpholinyl. Heterocyclyls include heteroaryls as defined herein, and examples of aromatic heterocyclyls are listed in the definition of heteroaryl below.

“Heteroaryl” refers to a 5- to 14-membered ring system radical comprising hydrogen atoms, one to thirteen carbon atoms, one to six heteroatoms selected from the group

consisting of nitrogen, oxygen and sulfur, and at least one aromatic ring. For purposes of this invention, the heteroaryl radical may be a stable 5-12 membered ring, a stable 5-10 membered ring, a stable 5-9 membered ring, a stable 5-8 membered ring, a stable 5-7 membered ring, or a stable 6 membered ring that comprises at least 1 heteroatom, at least 2 heteroatoms, at least 3 heteroatoms, at least 4 heteroatoms, at least 5 heteroatoms or at least 6 heteroatoms. Heteroaryls may be a monocyclic, bicyclic, tricyclic or tetracyclic ring system, which may include fused or bridged ring systems; and the nitrogen, carbon or sulfur atoms in the heteroaryl radical may be optionally oxidized; the nitrogen atom may be optionally quaternized. The heteroatom may be a member of an aromatic or non-aromatic ring, provided at least one ring in the heteroaryl is aromatic. Examples include, but are not limited to, azepinyl, acridinyl, benzimidazolyl, benzothiazolyl, benzindolyl, benzodioxolyl, benzofuranyl, benzoxazolyl, benzothiazolyl, benzothiadiazolyl, benzo[b][1,4]dioxepinyl, 1,4-benzodioxanyl, benzonaphthofuranyl, benzoxazolyl, benzodioxolyl, benzodioxinyl, benzopyranyl, benzopyranonyl, benzofuranyl, benzofuranonyl, benzothienyl (benzothiophenyl), benzotriazolyl, benzo[4,6]imidazo[1,2-a]pyridinyl, carbazolyl, cinnolinyl, dibenzofuranyl, dibenzothiophenyl, furanyl, furanonyl, isothiazolyl, imidazolyl, indazolyl, indolyl, indazolyl, isoindolyl, indolinyl, isoindolinyl, isoquinolyl, indolizinyl, isoxazolyl, naphthridinyl, oxadiazolyl, 2-oxoazepinyl, oxazolyl, oxiranyl, 1-oxidopyridinyl, 1-oxidopyrimidinyl, 1-oxidopyrazinyl, 1-oxidopyridazinyl, 1-phenyl-1H-pyrrolyl, phenazinyl, phenothiazinyl, phenoazinyl, phthalazinyl, pteridinyl, purinyl, pyrrolyl, pyrazolyl, pyridinyl, pyrazinyl, pyrimidinyl, pyridazinyl, quinazolinyl, quinoxalinyl, quinolinyl, quinuclidinyl, isoquinolinyl, tetrahydroquinolinyl, thiazolyl, thiadiazolyl, triazolyl, tetrazolyl, triazinyl, and thiophenyl (i.e. thiienyl).

“Thioalkyl” refers to a radical of the formula —SR_a where R_a is an alkyl radical as defined above containing one to twelve carbon atoms, at least 1-10 carbon atoms, at least 1-8 carbon atoms, at least 1-6 carbon atoms, or at least 1-4 carbon atoms.

“Thione” refers to a —S group attached to a carbon atom of a saturated or unsaturated (C₃-C₈)cyclic or a (C₁-C₈)acyclic moiety.

“Sulfoxide” refers to a —S(O)— group in which the sulfur atom is covalently attached to two carbon atoms.

“Sulfone” refers to a —S(O)₂— group in which a hexavalent sulfur is attached to each of the two oxygen atoms through double bonds and is further attached to two carbon atoms through single covalent bonds.

The compound of the invention can exist in various isomeric forms, as well as in one or more tautomeric forms, including both single tautomers and mixtures of tautomers. The term “isomer” is intended to encompass all isomeric forms of a compound of this invention, including tautomeric forms of the compound.

Some compounds described here can have asymmetric centers and therefore exist in different enantiomeric and diastereomeric forms. A compound of the invention can be in the form of an optical isomer or a diastereomer. Accordingly, the invention encompasses compounds of the invention and their uses as described herein in the form of their optical isomers, diastereoisomers and mixtures thereof, including a racemic mixture. Optical isomers of the compounds of the invention can be obtained by known techniques such as asymmetric synthesis, chiral chromatography, or via chemical separation of stereoisomers through the employment of optically active resolving agents.

Unless otherwise indicated, "stereoisomer" means one stereoisomer of a compound that is substantially free of other stereoisomers of that compound. Thus, a stereomerically pure compound having one chiral center will be substantially free of the opposite enantiomer of the compound. A stereomerically pure compound having two chiral centers will be substantially free of other diastereomers of the compound. A typical stereomerically pure compound comprises greater than about 80% by weight of one stereoisomer of the compound and less than about 20% by weight of other stereoisomers of the compound, for example greater than about 90% by weight of one stereoisomer of the compound and less than about 10% by weight of the other stereoisomers of the compound, or greater than about 95% by weight of one stereoisomer of the compound and less than about 5% by weight of the other stereoisomers of the compound, or greater than about 97% by weight of one stereoisomer of the compound and less than about 3% by weight of the other stereoisomers of the compound.

If there is a discrepancy between a depicted structure and a name given to that structure, then the depicted structure controls. Additionally, if the stereochemistry of a structure or a portion of a structure is not indicated with, for example, bold or dashed lines, the structure or portion of the structure is to be interpreted as encompassing all stereoisomers of it. In some cases, however, where more than one chiral center exists, the structures and names may be represented as single enantiomers to help describe the relative stereochemistry. Those skilled in the art of organic synthesis will know if the compounds are prepared as single enantiomers from the methods used to prepare them.

In this description, a "pharmaceutically acceptable salt" is a pharmaceutically acceptable, organic or inorganic acid or base salt of a compound of the invention. Representative pharmaceutically acceptable salts include, e.g., alkali metal salts, alkali earth salts, ammonium salts, water-soluble and water-insoluble salts, such as the acetate, amsonate (4,4-diaminostilbene-2,2-disulfonate), benzenesulfonate, benzoate, bicarbonate, bisulfate, bitartrate, borate, bromide, butyrate, calcium, calcium edetate, camsylate, carbonate, chloride, citrate, clavulariate, dihydrochloride, edetate, edisylate, estolate, esylate, fiunarate, gluceptate, gluconate, glutamate, glycolylarsanilate, hexafluorophosphate, hexylresorcinate, hydrabamine, hydrobromide, hydrochloride, hydroxynaphthoate, iodide, isothionate, lactate, lactobionate, laurate, maleate, maleate, mandelate, mesylate, methylbromide, methylnitrate, methylsulfate, mucate, napsylate, nitrate, N-methylglucamine ammonium salt, 3-hydroxy-2-naphthoate, oleate, oxalate, palmitate, pamoate (1,1-methylene-bis-2-hydroxy-3-naphthoate, einbonate), pantothenate, phosphate/diphosphate, picrate, polygalacturonate, propionate, p-toluenesulfonate, salicylate, stearate, subacetate, succinate, sulfate, sulfosaliculate, suramate, tannate, tartrate, teoclolate, tosylate, triethiodide, and valerate salts. A pharmaceutically acceptable salt can have more than one charged atom in its structure. In this instance the pharmaceutically acceptable salt can have multiple counterions. Thus, a pharmaceutically acceptable salt can have one or more charged atoms and/or one or more counterions.

The terms "treat", "treating" and "treatment" refer to the amelioration or eradication of a disease or symptoms associated with a disease. In certain embodiments, such terms refer to minimizing the spread or worsening of the disease resulting from the administration of one or more prophylactic or therapeutic agents to a patient with such a disease. In the context of the present invention the terms "treat", "treating" and "treatment" also refer to:

(i) preventing the disease or condition from occurring in a mammal, in particular, when such mammal is predisposed to the condition but has not yet been diagnosed as having it;

(ii) inhibiting the disease or condition, i.e., arresting its development;

(iii) relieving the disease or condition, i.e., causing regression of the disease or condition; or

(iv) relieving the symptoms resulting from the disease or condition, i.e., relieving pain without addressing the underlying disease or condition. As used herein, the terms "disease" and "condition" may be used interchangeably or may be different in that the particular malady or condition may not have a known causative agent (so that etiology has not yet been worked out) and it is therefore not yet recognized as a disease but only as an undesirable condition or syndrome, wherein a more or less specific set of symptoms have been identified by clinicians.

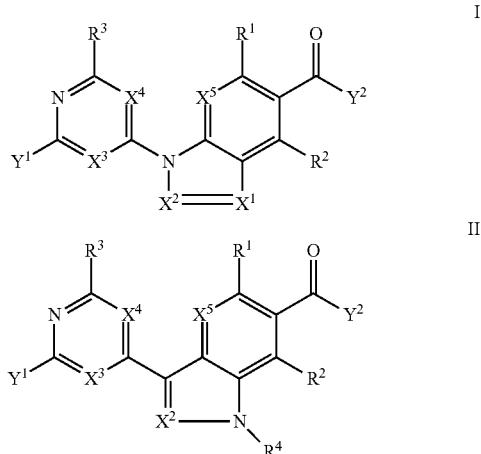
The terms "modulate", "modulation" and the like refer to the ability of a compound to increase or decrease the function, or activity of, for example, MAP kinase interacting kinase (Mnk). "Modulation", in its various forms, is intended to encompass inhibition, antagonism, partial antagonism, activation, agonism and/or partial agonism of the activity associated with Mnk. Mnk inhibitors are compounds that bind to, partially or totally block stimulation, decrease, prevent, delay activation, inactivate, desensitize, or down regulate signal transduction. The ability of a compound to modulate Mnk activity can be demonstrated in an enzymatic assay or a cell-based assay.

A "patient" or subject" includes an animal, such as a human, cow, horse, sheep, lamb, pig, chicken, turkey, quail, cat, dog, mouse, rat, rabbit or guinea pig. The animal can be a mammal such as a non-primate and a primate (e.g., monkey and human). In one embodiment, a patient is a human, such as a human infant, child, adolescent or adult.

The term "prodrug" refers to a precursor of a drug, a compound which upon administration to a patient, must undergo chemical conversion by metabolic processes before becoming an active pharmacological agent. Exemplary prodrugs of compounds in accordance with Formula I are esters, acetamides, and amides.

Compounds of the Invention

The present invention generally is directed to compounds encompassed by the genus of Formula I or Formula II, or a stereoisomer, a tautomer or a pharmaceutically acceptable salt thereof.



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For Formula I and Formula II compounds X^1 , X^2 , X^3 , X^4 , X^5 , Y^1 , Y^2 , R^1 , R^2 , R^3 , R^4 , R^5 , R^6 , R^7 , R^8 , R^9 , R^{10} , R^{11} , R^{12} and R^{13} are as defined in the specification. Also described below are specific embodiments of the Formula I and Formula II compounds.

In one embodiment X^1 is $-\text{CH}$.

In another embodiment X^1 is N .

In one embodiment X^2 is $-\text{CH}$.

In one embodiment X^3 is $-\text{CH}$.

In one embodiment X^4 is N .

In one embodiment X^5 is $-\text{CH}$.

In one embodiment Y^1 is NH_2 .

In one embodiment Y^2 is $\text{N}((\text{C}_1\text{-C}_8)\text{alkyl})_2$.

In another embodiment Y^2 is a heterocyclyl.

In one embodiment R^1 is $-\text{H}$, halogen or $-(\text{C}_1\text{-C}_8)\text{alkyl}$.

In one embodiment R^2 is $-\text{H}$, $-\text{OH}$, halogen, $-(\text{C}_1\text{-C}_8)\text{alkyl}$, $-(\text{C}_1\text{-C}_8)\text{haloalkyl}$, cycloalkyl, heterocyclyl, heteroaryl or aryl.

In another embodiment R^2 is halogen, cycloalkyl or heterocyclyl.

In one embodiment R^3 is $-\text{H}$.

In one embodiment R^4 is $-\text{H}$ or $-(\text{C}_1\text{-C}_8)\text{alkyl}$.

In one embodiment R^5 is $-\text{H}$ or $-(\text{C}_1\text{-C}_8)\text{alkyl}$.

In one embodiment R^6 is $-\text{H}$.

In one embodiment R^7 is $-\text{H}$, halogen or $-(\text{C}_1\text{-C}_8)\text{alkyl}$.

In one embodiment R^8 is $-\text{H}$.

In one embodiment R^9 and R^{10} are $-\text{H}$.

In one embodiment R^{11} and R^{12} are independently selected from $-(\text{C}_1\text{-C}_8)\text{alkyl}$, $-(\text{C}_1\text{-C}_8)\text{haloalkyl}$, heterocyclyl or cycloalkyl.

In one embodiment R^{13} is $-\text{H}$ or $-(\text{C}_1\text{-C}_8)\text{alkyl}$.

In another embodiment the compounds of the invention are selected from

1-(6-aminopyrimidin-4-yl)-6-chloro-1H-benzo[d]imidazole-5-carboxamide,

1-(6-aminopyrimidin-4-yl)-4-isobutyl-1H-benzo[d]imidazole-5-carboxamide,

1-(6-amino-5-methylpyrimidin-4-yl)-1H-benzo[d]imidazole-5-carboxamide,

1-(6-aminopyrimidin-4-yl)-2-methyl-1H-benzo[d]imidazole-5-carboxamide,

1-(6-aminopyrimidin-4-yl)-N,N-dimethyl-1H-benzo[d]imidazole-5-carboxamide,

1-(6-aminopyrimidin-4-yl)-6-chloro-4-isobutyl-1H-benzo[d]imidazole-5-carboxamide,

1-(6-aminopyrimidin-4-yl)-6-chloro-4-isobutyl-N-methyl-1H-benzo[d]imidazole-5-carboxamide,

1-(6-aminopyrimidin-4-yl)-6-chloro-4-isobutyl-N,N-dimethyl-1H-benzo[d]imidazole-5-carboxamide,

1-(6-aminopyrimidin-4-yl)-6-chloro-4-isobutyl-1H-benzo[d]imidazol-5-yl)(azetidin-1-yl)methanone,

1-(6-aminopyrimidin-4-yl)-6-chloro-4-isobutyl-1H-benzo[d]imidazol-5-yl)(pyrrolidin-1-yl)methanone,

1-(6-aminopyrimidin-4-yl)-4-isobutyl-N,N,6-trimethyl-1H-benzo[d]imidazole-5-carboxamide,

1-(6-amino-5-methylpyrimidin-4-yl)-4-isobutyl-N,N,6-trimethyl-1H-benzo[d]imidazole-5-carboxamide,

1-(6-amino-5-chloropyrimidin-4-yl)-4-isobutyl-N,N,6-trimethyl-1H-benzo[d]imidazole-5-carboxamide,

1-(6-aminopyrimidin-4-yl)-4-cyclohexyl-N,N,6-trimethyl-1H-benzo[d]imidazole-5-carboxamide,

1-(6-amino-5-methylpyrimidin-4-yl)-4-cyclohexyl-N,N,6-trimethyl-1H-benzo[d]imidazole-5-carboxamide,

1-(6-aminopyrimidin-4-yl)-4-cyclohexyl-N,N,6-trimethyl-1H-benzo[d]imidazole-5-carboxamide,

1-(6-amino-5-chloropyrimidin-4-yl)-4-cyclohexyl-N,N,6-trimethyl-1H-benzo[d]imidazole-5-carboxamide,

1-(6-aminopyrimidin-4-yl)-N,N,6-trimethyl-4-(1-methylpiperidin-3-yl)-1H-benzo[d]imidazole-5-carboxamide,

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1-(6-amino-5-methylpyrimidin-4-yl)-N,N,6-trimethyl-4-(1-methylpiperidin-3-yl)-1H-benzo[d]imidazole-5-carboxamide,

1-(6-amino-5-chloropyrimidin-4-yl)-N,N,6-trimethyl-4-(1-methylpiperidin-3-yl)-1H-benzo[d]imidazole-5-carboxamide,

1-(6-amino-5-methylpyrimidin-4-yl)-6-chloro-4-isobutyl-N,N-dimethyl-1H-benzo[d]imidazole-5-carboxamide,

1-(6-amino-5-chloropyrimidin-4-yl)-6-chloro-4-cyclohexyl-N,N-dimethyl-1H-benzo[d]imidazole-5-carboxamide,

1-(6-amino-5-methylpyrimidin-4-yl)-6-chloro-4-cyclohexyl-N,N-dimethyl-1H-benzo[d]imidazole-5-carboxamide,

1-(6-aminopyrimidin-4-yl)-6-chloro-N,N-dimethyl-4-(1-methylpiperidin-3-yl)-1H-benzo[d]imidazole-5-carboxamide,

1-(6-amino-5-methylpyrimidin-4-yl)-6-chloro-N,N-dimethyl-4-(1-methylpiperidin-3-yl)-1H-benzo[d]imidazole-5-carboxamide,

1-(6-aminopyrimidin-4-yl)-6-chloro-N,N-dimethyl-4-(1-methylpiperidin-3-yl)-1H-benzo[d]imidazole-5-carboxamide,

1-(6-aminopyrimidin-4-yl)-4-isobutyl-6-methyl-1H-benzo[d]imidazol-5-yl)(azetidin-1-yl)methanone,

1-(6-amino-5-methylpyrimidin-4-yl)-4-isobutyl-6-methyl-1H-benzo[d]imidazol-5-yl)(azetidin-1-yl)methanone,

1-(6-aminopyrimidin-4-yl)-4-cyclohexyl-6-methyl-1H-benzo[d]imidazol-5-yl)(azetidin-1-yl)methanone,

1-(6-amino-5-methylpyrimidin-4-yl)-4-cyclohexyl-6-methyl-1H-benzo[d]imidazol-5-yl)(azetidin-1-yl)methanone,

1-(6-aminopyrimidin-4-yl)-6-methyl-4-(1-methylpiperidin-3-yl)-1H-benzo[d]imidazol-5-yl)(azetidin-1-yl)methanone,

1-(6-amino-5-methylpyrimidin-4-yl)-6-methyl-4-(1-methylpiperidin-3-yl)-1H-benzo[d]imidazol-5-yl)(azetidin-1-yl)methanone,

1-(6-amino-5-methylpyrimidin-4-yl)-6-methyl-4-(1-methylpiperidin-3-yl)-1H-benzo[d]imidazol-5-yl)(azetidin-1-yl)methanone,

1-(6-amino-5-chloropyrimidin-4-yl)-6-chloro-4-isobutyl-1H-benzo[d]imidazol-5-yl)(azetidin-1-yl)methanone,

1-(6-aminopyrimidin-4-yl)-6-chloro-4-cyclohexyl-1H-benzo[d]imidazol-5-yl)(azetidin-1-yl)methanone,

1-(6-amino-5-methylpyrimidin-4-yl)-6-chloro-4-cyclohexyl-1H-benzo[d]imidazol-5-yl)(azetidin-1-yl)methanone,

1-(6-aminopyrimidin-4-yl)-6-chloro-4-cyclohexyl-1H-benzo[d]imidazol-5-yl)(azetidin-1-yl)methanone,

1-(6-aminopyrimidin-4-yl)-6-chloro-4-cyclohexyl-1H-benzo[d]imidazol-5-yl)(azetidin-1-yl)methanone,

1-(6-aminopyrimidin-4-yl)-6-chloro-4-(1-methylpiperidin-3-yl)-1H-benzo[d]imidazol-5-yl)(azetidin-1-yl)methanone,

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(1-(6-amino-5-methylpyrimidin-4-yl)-6-chloro-4-(1-methylpiperidin-3-yl)-1H-benzo[d]imidazol-5-yl)(azetidin-1-yl)methanone,
 (1-(6-amino-5-chloropyrimidin-4-yl)-6-chloro-4-(1-methylpiperidin-3-yl)-1H-benzo[d]imidazol-5-yl)(azetidin-1-yl)methanone,
 1-(6-aminopyrimidin-4-yl)-4-isobutyl-N,N,6-trimethyl-1H-indole-5-carboxamide,
 1-(6-amino-5-methylpyrimidin-4-yl)-4-isobutyl-N,N,6-trimethyl-1H-indole-5-carboxamide,
 1-(6-amino-5-chloropyrimidin-4-yl)-4-isobutyl-N,N,6-trimethyl-1H-indole-5-carboxamide,
 1-(6-aminopyrimidin-4-yl)-4-cyclohexyl-N,N,6-trimethyl-1H-indole-5-carboxamide,
 1-(6-amino-5-methylpyrimidin-4-yl)-4-cyclohexyl-N,N,6-trimethyl-1H-indole-5-carboxamide,
 1-(6-amino-5-chloropyrimidin-4-yl)-4-cyclohexyl-N,N,6-trimethyl-1H-indole-5-carboxamide,
 1-(6-aminopyrimidin-4-yl)-N,N,6-trimethyl-4-(1-methylpiperidin-3-yl)-1H-indole-5-carboxamide,
 1-(6-amino-5-methylpyrimidin-4-yl)-N,N,6-trimethyl-4-(1-methylpiperidin-3-yl)-1H-indole-5-carboxamide,
 1-(6-amino-5-chloropyrimidin-4-yl)-N,N,6-trimethyl-4-(1-methylpiperidin-3-yl)-1H-indole-5-carboxamide,
 1-(6-aminopyrimidin-4-yl)-6-chloro-4-isobutyl-N,N-dimethyl-1H-indole-5-carboxamide,
 1-(6-amino-5-methylpyrimidin-4-yl)-6-chloro-4-isobutyl-N,N-dimethyl-1H-indole-5-carboxamide,
 1-(6-amino-5-chloropyrimidin-4-yl)-6-chloro-4-isobutyl-N,N-dimethyl-1H-indole-5-carboxamide,
 1-(6-aminopyrimidin-4-yl)-6-chloro-4-cyclohexyl-N,N-dimethyl-1H-indole-5-carboxamide,
 1-(6-amino-5-methylpyrimidin-4-yl)-6-chloro-4-cyclohexyl-N,N-dimethyl-1H-indole-5-carboxamide,
 1-(6-amino-5-chloropyrimidin-4-yl)-6-chloro-4-cyclohexyl-N,N-dimethyl-1H-indole-5-carboxamide,
 1-(6-aminopyrimidin-4-yl)-6-chloro-N,N-dimethyl-4-(1-methylpiperidin-3-yl)-1H-indole-5-carboxamide,
 1-(6-amino-5-methylpyrimidin-4-yl)-6-chloro-N,N-dimethyl-4-(1-methylpiperidin-3-yl)-1H-indole-5-carboxamide,
 1-(6-amino-5-chloropyrimidin-4-yl)-6-chloro-N,N-dimethyl-4-(1-methylpiperidin-3-yl)-1H-indole-5-carboxamide,
 (1-(6-aminopyrimidin-4-yl)-4-isobutyl-6-methyl-1H-indol-5-yl)(azetidin-1-yl)methanone,
 (1-(6-amino-5-methylpyrimidin-4-yl)-4-isobutyl-6-methyl-1H-indol-5-yl)(azetidin-1-yl)methanone,
 (1-(6-amino-5-chloropyrimidin-4-yl)-4-isobutyl-6-methyl-1H-indol-5-yl)(azetidin-1-yl)methanone,
 (1-(6-aminopyrimidin-4-yl)-4-cyclohexyl-6-methyl-1H-indol-5-yl)(azetidin-1-yl)methanone,
 (1-(6-amino-5-methylpyrimidin-4-yl)-4-cyclohexyl-6-methyl-1H-indol-5-yl)(azetidin-1-yl)methanone,
 (1-(6-amino-5-chloropyrimidin-4-yl)-4-cyclohexyl-6-methyl-1H-indol-5-yl)(azetidin-1-yl)methanone,
 (1-(6-aminopyrimidin-4-yl)-6-methyl-4-(1-methylpiperidin-3-yl)-1H-indol-5-yl)(azetidin-1-yl)methanone,
 (1-(6-amino-5-methylpyrimidin-4-yl)-6-methyl-4-(1-methylpiperidin-3-yl)-1H-indol-5-yl)(azetidin-1-yl)methanone,
 (1-(6-amino-5-chloropyrimidin-4-yl)-6-methyl-4-(1-methylpiperidin-3-yl)-1H-indol-5-yl)(azetidin-1-yl)methanone,
 (1-(6-aminopyrimidin-4-yl)-6-chloro-4-isobutyl-1H-indol-5-yl)(azetidin-1-yl)methanone

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(1-(6-amino-5-methylpyrimidin-4-yl)-6-chloro-4-isobutyl-1H-indol-5-yl)(azetidin-1-yl)methanone,
 (1-(6-amino-5-chloropyrimidin-4-yl)-6-chloro-4-isobutyl-1H-indol-5-yl)(azetidin-1-yl)methanone,
 5 (1-(6-aminopyrimidin-4-yl)-6-chloro-4-cyclohexyl-1H-indol-5-yl)(azetidin-1-yl)methanone,
 (1-(6-amino-5-methylpyrimidin-4-yl)-6-chloro-4-cyclohexyl-1H-indol-5-yl)(azetidin-1-yl)methanone,
 10 (1-(6-amino-5-chloropyrimidin-4-yl)-6-chloro-4-cyclohexyl-1H-indol-5-yl)(azetidin-1-yl)methanone,
 (1-(6-aminopyrimidin-4-yl)-6-chloro-4-(1-methylpiperidin-3-yl)-1H-indol-5-yl)(azetidin-1-yl)methanone,
 (1-(6-amino-5-methylpyrimidin-4-yl)-6-chloro-4-(1-methylpiperidin-3-yl)-1H-indol-5-yl)(azetidin-1-yl)methanone,
 15 (1-(6-amino-5-chloropyrimidin-4-yl)-6-chloro-4-(1-methylpiperidin-3-yl)-1H-indol-5-yl)(azetidin-1-yl)methanone,
 (1-(6-amino-5-chloropyrimidin-4-yl)-6-chloro-4-(1-methylpiperidin-3-yl)-1H-indol-5-yl)(azetidin-1-yl)methanone,
 ((1-(6-aminopyrimidin-4-yl)-6-chloro-4-(1-methylpiperidin-3-yl)-1H-indol-5-yl)(azetidin-1-yl)methanone,
 20 (1-(6-aminopyrimidin-4-yl)-6-chloro-4-(1-methylpiperidin-3-yl)-1H-benzo[d][1,2,3]triazol-5-yl)(azetidin-1-yl)methanone,
 (1-(6-aminopyrimidin-4-yl)-6-chloro-4-(1-methylpiperidin-3-yl)-1H-indol-6-yl)(azetidin-1-yl)methanone,
 25 (3-(6-aminopyrimidin-4-yl)-5-chloro-1-methyl-7-(1-methylpiperidin-3-yl)-1H-indol-6-yl)(azetidin-1-yl)methanone,
 (3-(6-aminopyrimidin-4-yl)-5-chloro-1-methyl-7-(1-methylpiperidin-3-yl)-1H-indazol-6-yl)(azetidin-1-yl)methanone,
 30 (3-(6-aminopyrimidin-4-yl)-5-chloro-1-methyl-7-(1-methylpiperidin-3-yl)-1H-pyrrolo[3,2-b]pyridin-6-yl)(azetidin-1-yl)methanone,
 (3-(6-aminopyrimidin-4-yl)-5-chloro-1-methyl-7-(1-methylpiperidin-3-yl)-1H-pyrazolo[4,3-b]pyridin-6-yl)(azetidin-1-yl)methanone,
 35 1-(6-amino-5-chloropyrimidin-4-yl)-4-isobutyl-1H-indole-5-carboxamide,
 3-(6-aminopyrimidin-4-yl)-7-isobutyl-1-methyl-1H-indole-6-carboxamide,
 40 1-(6-amino-5-chloropyrimidin-4-yl)-4-isobutyl-N,N-dimethyl-1H-benzo[d]imidazole-5-carboxamide,
 1-(6-aminopyrimidin-4-yl)-4-isobutyl-N,N-dimethyl-1H-benzo[d]imidazole-5-carboxamide,
 45 1-(6-amino-5-chloropyrimidin-4-yl)-4-isobutyl-1H-indazole-5-carboxamide,
 1-(6-amino-5-chloropyrimidin-4-yl)-4-isobutyl-1H-benzo[d]imidazole-5-carboxamide.

The inventive compounds according to Formula I and Formula II may be isotopically-labelled by having one or 50 more atoms replaced by an atom having a different atomic mass or mass number. Examples of isotopes that can be incorporated into compounds of according to Formula I and Formula II include isotopes of hydrogen, carbon, nitrogen, oxygen, phosphorous, fluorine, chlorine, or iodine. Illustrative of such isotopes are ^2H , ^3H , ^{11}C , ^{13}C , ^{14}C , ^{13}N , ^{15}N , ^{15}O , ^{17}O , ^{18}O , ^{31}P , ^{32}P , ^{35}S , ^{18}F , ^{36}Cl , ^{123}I , and ^{125}I , respectively. These radiolabelled compounds can be used to measure the biodistribution, tissue concentration and the kinetics of transport and excretion from biological tissues including a 55 subject to which such a labelled compound is administered. Labeled compounds are also used to determine therapeutic effectiveness, the site or mode of action, and the binding affinity of a candidate therapeutic to a pharmacologically important target. Certain radioactive-labelled compounds according to Formula I and Formula II, therefore, are useful 60 in drug and/or tissue distribution studies. The radioactive isotopes tritium, i.e. ^3H , and carbon-14, i.e. ^{14}C , are par-

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ticularly useful for this purpose in view of their ease of incorporation and ready means of detection.

Substitution with heavier isotopes such as deuterium, i.e. ²H, affords certain therapeutic advantages resulting from the greater metabolic stability, for example, increased *in vivo* half-life of compounds containing deuterium. Substitution of hydrogen with deuterium may reduce dose required for therapeutic effect, and hence may be preferred in a discovery or clinical setting.

Substitution with positron emitting isotopes, such as ¹¹C, ¹⁸F, ¹⁵O and ¹³N, provides labeled analogs of the inventive compounds that are useful in Positron Emission Tomography (PET) studies, e.g., for examining substrate receptor occupancy. Isotopically-labeled compounds according to Formula I or Formula II can generally be prepared by conventional techniques known to those skilled in the art or by processes analogous to those described in the Preparations and Examples section as set out below using an appropriate isotopic-labeling reagent.

Embodiments of the invention disclosed herein are also meant to encompass the *in vivo* metabolic products of compounds according to Formula I and Formula II. Such products may result from, for example, the oxidation, reduction, hydrolysis, amidation, esterification, and like processes primarily due to enzymatic activity upon administration of a compound of the invention. Accordingly, the invention includes compounds that are produced as by-products of enzymatic or non-enzymatic activity on an inventive compound following the administration of such a compound to a mammal for a period of time sufficient to yield a metabolic product. Metabolic products, particularly pharmaceutically active metabolites are typically identified by administering a radiolabelled compound of the invention in a detectable dose to a subject, such as rat, mouse, guinea pig, monkey, or human, for a sufficient period of time during which metabolism occurs, and isolating the metabolic products from urine, blood or other biological samples that are obtained from the subject receiving the radiolabelled compound.

The invention also provides pharmaceutically acceptable salt forms of Formula I and Formula II compounds. Encompassed within the scope of the invention are both acid and base addition salts that are formed by contacting a pharmaceutically suitable acid or a pharmaceutically suitable base with a compound of the invention.

A "pharmaceutically acceptable acid addition salt" refers to those salts which retain the biological effectiveness and properties of the free bases, which are not biologically or otherwise undesirable, and which are formed with inorganic acids such as, but are not limited to, hydrochloric acid, hydrobromic acid, sulfuric acid, nitric acid, phosphoric acid and the like, and organic acids such as, but not limited to, acetic acid, 2,2-dichloroacetic acid, adipic acid, alginic acid, ascorbic acid, aspartic acid, benzenesulfonic acid, benzoic acid, 4-acetamidobenzoic acid, camphoric acid, camphor-10-sulfonic acid, capric acid, caproic acid, caprylic acid, carbonic acid, cinnamic acid, citric acid, cyclamic acid, dodecylsulfuric acid, ethane-1,2-disulfonic acid, ethanesulfonic acid, 2-hydroxyethanesulfonic acid, formic acid, fumaric acid, galactaric acid, gentisic acid, glucoheptonic acid, gluconic acid, glucuronic acid, glutamic acid, glutaric acid, 2-oxo-glutaric acid, glycerophosphoric acid, glycolic acid, hippuric acid, isobutyric acid, lactic acid, lactobionic acid, lauric acid, maleic acid, malic acid, malonic acid, mandelic acid, methanesulfonic acid, mucic acid, naphthalene-1,5-disulfonic acid, naphthalene-2-sulfonic acid, 1-hydroxy-2-naphthoic acid, nicotinic acid, oleic acid, orotic acid, oxalic acid, palmitic acid, pamoic acid, propionic acid,

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pyroglutamic acid, pyruvic acid, salicylic acid, 4-aminosalicylic acid, sebacic acid, stearic acid, succinic acid, tartaric acid, thiocyanic acid, p-toluenesulfonic acid, trifluoroacetic acid, undecylenic acid, and the like.

5 A "pharmaceutically acceptable base addition salt" refers to those salts which retain the biological effectiveness and properties of the free acids, which are not biologically or otherwise undesirable. These salts are prepared by addition of an inorganic base or an organic base to the free acid. Salts 10 derived from inorganic bases include, but are not limited to, the sodium, potassium, lithium, ammonium, calcium, magnesium, iron, zinc, copper, manganese, aluminum salts and the like. Preferred inorganic salts are the ammonium, sodium, potassium, calcium, and magnesium salts. Salts 15 derived from organic bases include, but are not limited to, salts of primary, secondary, and tertiary amines, substituted amines including naturally occurring substituted amines, cyclic amines and basic ion exchange resins, such as ammonia, isopropylamine, trimethylamine, diethylamine, triethylamine, tripropylamine, diethanolamine, ethanolamine, deanol, 2-dimethylaminoethanol, 2-diethylaminoethanol, dicyclohexylamine, lysine, arginine, histidine, caffeine, procaine, hydрабamine, choline, betaine, benethamine, benzathine, ethylenediamine, glucosamine, methylglucamine, 25 theobromine, triethanolamine, tromethamine, purines, piperazine, piperidine, N-ethylpiperidine, polyamine resins and the like. Particularly preferred organic bases are isopropylamine, diethylamine, ethanolamine, trimethylamine, dicyclohexylamine, choline and caffeine.

30 Often crystallizations produce a solvate of the compound of the invention. As used herein, the term "solvate" refers to an aggregate that comprises one or more molecules of a compound of the invention with one or more molecules of solvent. The solvent may be water, in which case the solvate 35 may be a hydrate. Alternatively, the solvent may be an organic solvent. Thus, the compounds of the present invention may exist as a hydrate, including a monohydrate, dihydrate, hemihydrate, sesquihydrate, trihydrate, tetrhydrate and the like, as well as the corresponding solvated forms. The compound of the invention may be true solvates, 40 while in other cases, the compound of the invention may merely retain adventitious water or be a mixture of water plus some adventitious solvent.

45 A "stereoisomer" refers to a compound made up of the same atoms bonded by the same bonds but having different three-dimensional structures, which are not interchangeable. The present invention contemplates various stereoisomers and mixtures thereof and includes "enantiomers", which refers to two stereoisomers whose molecules are nonsuperimposeable mirror images of one another.

50 Compounds of the invention, or their pharmaceutically acceptable salts may contain one or more asymmetric centers and may thus give rise to enantiomers, diastereomers, and other stereoisomeric forms that may be defined, in terms 55 of absolute stereochemistry, as (R)- or (S)- or, as (D)- or (L)- for amino acids. The present invention is meant to include all such possible isomers, as well as their racemic and optically pure forms. Optically active (+) and (-), (R)- and (S)-, or (D)- and (L)-isomers may be prepared using chiral synthons 60 or chiral reagents, or resolved using conventional techniques, for example, chromatography and fractional crystallization. Conventional techniques for the preparation/isolation of individual enantiomers include chiral synthesis from a suitable optically pure precursor or resolution of the 65 racemate (or the racemate of a salt or derivative) using, for example, chiral high pressure liquid chromatography (HPLC). When the compounds described herein contain

olefinic double bonds or other centers of geometric asymmetry, and unless specified otherwise, it is intended that the compounds include both E and Z geometric isomers. Likewise, all tautomeric forms are also intended to be included.

The term "tautomer" refers to a proton shift from one atom of a molecule to another atom of the same molecule.

The inventive compounds are synthesized using conventional synthetic methods, and more specifically using the general methods noted below. Specific synthetic protocols for compounds in accordance with the present invention are described in the Examples.

Pharmaceutical Formulations

In one embodiment, compounds according to Formula I and Formula II are formulated as pharmaceutically acceptable compositions that contain a Formula I or Formula II compound in an amount effective to treat a particular disease or condition of interest upon administration of the pharmaceutical composition to a mammal. Pharmaceutical compositions in accordance with the present invention can comprise a Formula I or Formula II compound in combination with a pharmaceutically acceptable carrier, diluent or excipient.

In this regard, a "pharmaceutically acceptable carrier, diluent or excipient" includes without limitation any adjuvant, carrier, excipient, glidant, sweetening agent, diluent, preservative, dye/colorant, flavor enhancer, surfactant, wetting agent, dispersing agent, suspending agent, stabilizer, isotonic agent, solvent, or emulsifier which has been approved by the United States Food and Drug Administration as being acceptable for use in humans or domestic animals.

Further, a "mammal" includes humans and both domestic animals such as laboratory animals and household pets (e.g., cats, dogs, swine, cattle, sheep, goats, horses, rabbits), and non-domestic animals such as wildlife and the like.

The pharmaceutical compositions of the invention can be prepared by combining a compound of the invention with an appropriate pharmaceutically acceptable carrier, diluent or excipient, and may be formulated into preparations in solid, semi-solid, liquid or gaseous forms, such as tablets, capsules, powders, granules, ointments, solutions, suppositories, injections, inhalants, gels, microspheres, and aerosols. Typical routes of administering such pharmaceutical compositions include, without limitation, oral, topical, transdermal, inhalation, parenteral, sublingual, buccal, rectal, vaginal, and intranasal. The term parenteral as used herein includes subcutaneous injections, intravenous, intramuscular, intrasternal injection or infusion techniques. Pharmaceutical compositions of the invention are formulated so as to allow the active ingredients contained therein to be bioavailable upon administration of the composition to a patient. Compositions that will be administered to a subject or patient take the form of one or more dosage units, where for example, a tablet may be a single dosage unit, and a container of a compound of the invention in aerosol form may hold a plurality of dosage units. Actual methods of preparing such dosage forms are known, or will be apparent, to those skilled in this art; for example, see Remington: The Science and Practice of Pharmacy, 20th Edition (Philadelphia College of Pharmacy and Science, 2000). The composition to be administered will, in any event, contain a therapeutically effective amount of a compound of the invention, or a pharmaceutically acceptable salt thereof, for treatment of a disease or condition of interest in accordance with the teachings of this invention.

A pharmaceutical composition of the invention may be in the form of a solid or liquid. In one aspect, the carrier(s) are

particulate, so that the compositions are, for example, in tablet or powder form. The carrier(s) may be liquid, with the compositions being, for example, an oral syrup, injectable liquid or an aerosol, which is useful in, for example, inhalatory administration. When intended for oral administration, the pharmaceutical composition is preferably in either solid or liquid form, where semi-solid, semi-liquid, suspension and gel forms are included within the forms considered herein as either solid or liquid.

As a solid composition for oral administration the pharmaceutical composition may be formulated into a powder, granule, compressed tablet, pill, capsule, chewing gum, wafer or the like form. Such a solid composition will typically contain one or more inert diluents or edible carriers. In addition, one or more of the following may be present: binders such as carboxymethylcellulose, ethyl cellulose, microcrystalline cellulose, gum tragacanth or gelatin; excipients such as starch, lactose or dextrins, disintegrating agents such as alginic acid, sodium alginate, Primogel, corn starch and the like; lubricants such as magnesium stearate or Sterotex; glidants such as colloidal silicon dioxide; sweetening agents such as sucrose or saccharin; a flavoring agent such as peppermint, methyl salicylate or orange flavoring; and a coloring agent.

When the pharmaceutical composition is in the form of a capsule, for example, a gelatin capsule, it may contain, in addition to materials of the above type, a liquid carrier such as polyethylene glycol or oil.

The pharmaceutical composition may be in the form of a liquid, for example, an elixir, syrup, solution, emulsion or suspension. The liquid may be for oral administration or for delivery by injection, as two examples. When intended for oral administration, preferred composition contain, in addition to the present compounds, one or more of a sweetening agent, preservatives, dye/colorant and flavor enhancer. In a composition intended to be administered by injection, one or more of a surfactant, preservative, wetting agent, dispersing agent, suspending agent, buffer, stabilizer and isotonic agent may be included.

The liquid pharmaceutical compositions of the invention, whether they be solutions, suspensions or other like form, may include one or more of the following adjuvants: sterile diluents such as water for injection, saline solution, preferably physiological saline, Ringer's solution, isotonic sodium chloride, fixed oils such as synthetic mono or diglycerides which may serve as the solvent or suspending medium, polyethylene glycols, glycerin, propylene glycol or other solvents; antibacterial agents such as benzyl alcohol or methyl paraben; antioxidants such as ascorbic acid or sodium bisulfite; chelating agents such as ethylenediaminetetraacetic acid; buffers such as acetates, citrates or phosphates and agents for the adjustment of tonicity such as sodium chloride or dextrose. The parenteral preparation can be enclosed in ampoules, disposable syringes or multiple dose vials made of glass or plastic. Physiological saline is a preferred adjuvant. An injectable pharmaceutical composition is preferably sterile.

A liquid pharmaceutical composition of the invention intended for either parenteral or oral administration should contain an amount of a compound of the invention such that a suitable dosage will be obtained.

The pharmaceutical composition of the invention may be intended for topical administration, in which case the carrier may suitably comprise a solution, emulsion, ointment or gel base. The base, for example, may comprise one or more of the following: petrolatum, lanolin, polyethylene glycols, bee wax, mineral oil, diluents such as water and alcohol, and

emulsifiers and stabilizers. Thickening agents may be present in a pharmaceutical composition for topical administration. If intended for transdermal administration, the composition may include a transdermal patch or iontophoresis device.

The pharmaceutical composition of the invention may be intended for rectal administration, in the form, for example, of a suppository, which will melt in the rectum and release the drug. The composition for rectal administration may contain an oleaginous base as a suitable nonirritating excipient. Such bases include, without limitation, lanolin, cocoa butter and polyethylene glycol.

The pharmaceutical composition of the invention may include various materials, which modify the physical form of a solid or liquid dosage unit. For example, the composition may include materials that form a coating shell around the active ingredients. The materials that form the coating shell are typically inert, and may be selected from, for example, sugar, shellac, and other enteric coating agents. Alternatively, the active ingredients may be encased in a gelatin capsule.

The pharmaceutical composition of the invention in solid or liquid form may include an agent that binds to the compound of the invention and thereby assists in the delivery of the compound. Suitable agents that may act in this capacity include a monoclonal or polyclonal antibody, a protein or a liposome.

The pharmaceutical composition of the invention may consist of dosage units that can be administered as an aerosol. The term aerosol is used to denote a variety of systems ranging from those of colloidal nature to systems consisting of pressurized packages. Delivery may be by a liquefied or compressed gas or by a suitable pump system that dispenses the active ingredients. Aerosols of compounds of the invention may be delivered in single phase, bi-phasic, or tri-phasic systems in order to deliver the active ingredient (s). Delivery of the aerosol includes the necessary container, activators, valves, subcontainers, and the like, which together may form a kit. One skilled in the art, without undue experimentation may determine preferred aerosols.

The pharmaceutical compositions of the invention may be prepared by any methodology well known in the pharmaceutical art. For example, a pharmaceutical composition intended to be administered by injection can be prepared by combining a compound of the invention with sterile, distilled water so as to form a solution. A surfactant may be added to facilitate the formation of a homogeneous solution or suspension. Surfactants are compounds that non-covalently interact with the compound of the invention so as to facilitate dissolution or homogeneous suspension of the compound in the aqueous delivery system.

In certain embodiments a pharmaceutical composition comprising a compound of Formula I or Formula II is administered to a mammal in an amount sufficient to inhibit Mnk activity upon administration, and preferably with acceptable toxicity to the same. Mnk activity of Formula I and Formula II compounds can be determined by one skilled in the art, for example, as described in the Examples below. Appropriate concentrations and dosages can be readily determined by one skilled in the art.

Therapeutic Use

The compounds of the invention, or their pharmaceutically acceptable salts, are administered in a therapeutically effective amount, which will vary depending upon a variety of factors including the activity of the specific compound employed; the metabolic stability and length of action of the compound; the age, body weight, general health, sex, and

diet of the patient; the mode and time of administration; the rate of excretion; the drug combination; the severity of the particular disorder or condition; and the subject undergoing therapy.

“Effective amount” or “therapeutically effective amount” refers to that amount of a compound of the invention which, when administered to a mammal, preferably a human, is sufficient to effect treatment, as defined below, of a Mnk related condition or disease in the mammal, preferably a human. The amount of a compound of the invention which constitutes a “therapeutically effective amount” will vary depending on the compound, the condition and its severity, the manner of administration, and the age of the mammal to be treated, but can be determined routinely by one of ordinary skill in the art having regard to his own knowledge and to this disclosure.

Compounds of the invention, or pharmaceutically acceptable salt thereof, may also be administered simultaneously with, prior to, or after administration of one or more other therapeutic agents. Such combination therapy includes administration of a single pharmaceutical dosage formulation which contains a compound of the invention and one or more additional active agents, as well as administration of the compound of the invention and each active agent in its own separate pharmaceutical dosage formulation. For example, a compound of the invention and the other active agent can be administered to the patient together in a single oral dosage composition such as a tablet or capsule, or each agent administered in separate oral dosage formulations. Where separate dosage formulations are used, the compounds of the invention and one or more additional active agents can be administered at essentially the same time, i.e., concurrently, or at separately staggered times, i.e., sequentially; combination therapy is understood to include all these regimens.

In certain embodiments the disclosed compounds are useful for inhibiting the activity of Mnk and/or can be useful in analyzing Mnk signaling activity in model systems and/or for preventing, treating, or ameliorating a symptom associated with a disease, disorder, or pathological condition involving Mnk, preferably one afflicting humans. A compound which inhibits the activity of Mnk will be useful in preventing, treating, ameliorating, or reducing the symptoms or progression of diseases of uncontrolled cell growth, proliferation and/or survival, inappropriate cellular immune responses, or inappropriate cellular inflammatory responses or diseases which are accompanied with uncontrolled cell growth, proliferation and/or survival, inappropriate cellular immune responses, or inappropriate cellular inflammatory responses, particularly in which the uncontrolled cell growth, proliferation and/or survival, inappropriate cellular immune responses, or inappropriate cellular inflammatory responses is mediated by Mnk, such as, for example, haematological tumors, solid tumors, and/or metastases thereof, including leukaemias and myelodysplastic syndrome, Waldenstrom macroglobulinemia, and malignant lymphomas, for example, B-cell lymphoma, T-cell lymphoma, hairy cell lymphoma, Hodgkin's lymphoma, non-Hodgkin's lymphoma, and Burkitt's lymphoma, head and neck tumors including brain tumors and brain metastases, tumors of the thorax including non-small cell and small cell lung tumors, gastrointestinal tumors, endocrine tumors, mammary and other gynecological tumors, urological tumors including renal, bladder and prostate tumors, skin tumors, and sarcomas, and/or metastases thereof.

Furthermore, the inventive compounds and their pharmaceutical compositions are candidate therapeutics for the

prophylaxis and/or therapy of cytokine related diseases, such as inflammatory diseases, allergies, or other conditions associated with proinflammatory cytokines. Exemplary inflammatory diseases include without limitation, chronic or acute inflammation, inflammation of the joints such as chronic inflammatory arthritis, rheumatoid arthritis, psoriatic arthritis, osteoarthritis, juvenile rheumatoid arthritis, Reiter's syndrome, rheumatoid traumatic arthritis, rubella arthritis, acute synovitis and gouty arthritis; inflammatory skin diseases such as sunburn, psoriasis, erythrodermic psoriasis, pustular psoriasis, eczema, dermatitis, acute or chronic graft formation, atopic dermatitis, contact dermatitis, urticaria and scleroderma; inflammation of the gastrointestinal tract such as inflammatory bowel disease, Crohn's disease and related conditions, ulcerative colitis, colitis, and diverticulitis; nephritis, urethritis, salpingitis, oophoritis, endomyometritis, spondylitis, systemic lupus erythematosus and related disorders, multiple sclerosis, asthma, meningitis, myelitis, encephalomyelitis, encephalitis, phlebitis, thrombophlebitis, respiratory diseases such as asthma, bronchitis, chronic obstructive pulmonary disease (COPD), inflammatory lung disease and adult respiratory distress syndrome, and allergic rhinitis; endocarditis, osteomyelitis, rheumatic fever, rheumatic pericarditis, rheumatic endocarditis, rheumatic myocarditis, rheumatic mitral valve disease, rheumatic aortic valve disease, prostatitis, prostatocystitis, spondarthropathies ankylosing spondylitis, synovitis, tenosynovitis, myositis, pharyngitis, polymyalgia rheumatica, shoulder tendonitis or bursitis, gout, pseudo gout, vasculitides, inflammatory diseases of the thyroid selected from granulomatous thyroiditis, lymphocytic thyroiditis, invasive fibrous thyroiditis, acute thyroiditis; Hashimoto's thyroiditis, Kawasaki's disease, Raynaud's phenomenon, Sjogren's syndrome, neuroinflammatory disease, sepsis, conjunctivitis, keratitis, iridocyclitis, optic neuritis, otitis, lymphadenitis, nasopaharingitis, sinusitis, pharyngitis, tonsillitis, laryngitis, epiglottitis, bronchitis, pneumonitis, stomatitis, gingivitis, oesophagitis, gastritis, peritonitis, hepatitis, cholelithiasis, cholecystitis, glomerulonephritis, goodpasture's disease, crescentic glomerulonephritis, pancreatitis, endomyometritis, myometritis, metritis, cervicitis, endocervicitis, exocervicitis, parametritis, tuberculosis, vaginitis, vulvitis, silicosis, sarcoidosis, pneumoconiosis, pyresis, inflammatory polyarthropathies, psoriatic arthropathies, intestinal fibrosis, bronchiectasis and enteropathic arthropathies.

Although inflammation is the unifying pathogenic process of these diseases, current therapies only treat the symptoms of the disease and not the underlying cause of inflammation. The compositions of the present invention are useful for the treatment and/or prophylaxis of inflammatory diseases and related complications and disorders.

Accordingly, certain embodiments are directed to a method for treating a MnK dependent condition in a mammal in need thereof, the method comprising administering an effective amount of a pharmaceutical composition as described above (i.e., a pharmaceutical composition comprising any one or more compounds of Formula I and Formula II) to a mammal.

As described above deregulation of protein synthesis is a common event in human cancers. A key regulator of translational control is eIF4E whose activity is a key determinant of tumorigenicity. Because activation of eIF4E involves phosphorylation of a key serine (Ser209) specifically by MAP kinase interacting kinases (Mnk), inhibitors of MnK are suitable candidate therapeutics for treating cell proliferative disorders such as cancer. A wide variety of cancers,

including solid tumors, lymphomas and leukemias, are amenable to the compositions and methods disclosed herein. Types of cancer that may be treated include, but are not limited to: adenocarcinoma of the breast, prostate and colon; 5 all forms of bronchogenic carcinoma of the lung; myeloid; melanoma; hepatoma; neuroblastoma; papilloma; apudoma; choristoma; bronchioma; malignant carcinoid syndrome; carcinoid heart disease; and carcinoma (e.g., Walker, basal cell, basosquamous, Brown-Pearce, ductal, Ehrlich tumor, 10 Krebs 2, merkel cell, mucinous, non-small cell lung, oat cell, papillary, scirrhous, bronchiolar, bronchogenic, squamous cell, and transitional cell). Additional types of cancers that may be treated include: histiocytic disorders; acute and 15 chronic leukemia, both myeloid and lymphoid/lymphoblastic, including hairy cell leukemia; histiocytosis malignant; Hodgkin's disease; immunoproliferative small; Hodgkin's lymphoma; B-cell and T-cell non-Hodgkin's lymphoma, including diffuse large B-cell and Burkitt's lymphoma; plasmacytoma; reticuloendotheliosis; melanoma; multiple 20 myeloma; chondroblastoma; chondroma; chondrosarcoma; fibroma; fibrosarcoma; myelofibrosis; giant cell tumors; histiocytoma; lipoma; liposarcoma; mesothelioma; myxoma; myxosarcoma; osteoma; osteosarcoma; chondroma; craniopharyngioma; dysgerminoma; hamartoma; 25 mesenchymoma; mesonephroma; myosarcoma; ameloblastoma; cementoma; odontoma; teratoma; thymoma; trophoblastic tumor.

Other cancers that can be treated using the inventive compounds include without limitation adenoma; cholangioma; cholesteatoma; cyclindroma; cystadenocarcinoma; cystadenoma; granulosa cell tumor; gynandroblastoma; hepatoma; hidradenoma; islet cell tumor; Leydig cell tumor; papilloma; sertoli cell tumor; theca cell tumor; leimyoma; leiomyosarcoma; myoblastoma; myomma; myosarcoma; 30 rhabdomyoma; rhabdomyosarcoma; ependymoma; ganglioneuroma; glioma; medulloblastoma; meningioma; neurilemmoma; neuroblastoma; neuroepithelioma; neurofibroma; neuroma; paraganglioma; paraganglioma nonchromaffin.

40 In one embodiment the inventive compounds are candidate therapeutic agents for the treatment of cancers such as angiokeratoma; angiolympoid hyperplasia with eosinophilia; angioma sclerosing; angiomas; glomangioma; hemangioblastoma; hemangioma; hemangiopericytoma; hemangiopericytoma; hemangiosarcoma; lymphangioma; lymphangiomyoma; lymphangiosarcoma; pinealoma; carcinosarcoma; chondrosarcoma; cystosarcoma phyllodes; fibrosarcoma; hemangiosarcoma; leiomyosarcoma; leukosarcoma; liposarcoma; lymphangiosarcoma; myosarcoma; myxosarcoma; ovarian carcinoma; rhabdomyosarcoma; sarcoma; neoplasms; nerofibromatosis; and cervical dysplasia.

45 In a particular embodiment the present disclosure provides methods for treating colon cancer, colorectal cancer, gastric cancer, thyroid cancer, lung cancer, leukemia, pancreatic cancer, melanoma, multiple melanoma, brain cancer, primary and secondary CNS cancer, including malignant glioma and glioblastoma, renal cancer, prostate cancer, including castration-resistant prostate cancer, ovarian cancer, or breast cancer, including triple negative, HER2 positive, and hormone receptor positive breast cancers. According to such a method, a therapeutically effective amount of at least one compound according to Formula I or Formula II or a stereoisomer, tautomer or pharmaceutically acceptable salt thereof can be administered to a subject who has been 50 diagnosed with a cell proliferative disease, such as a cancer. Alternatively, a pharmaceutical composition comprising at least one compound according to Formula I or Formula II or

a stereoisomer, tautomer or pharmaceutically acceptable salt thereof can be administered to a subject who has been diagnosed with cancer.

In certain embodiments the compounds in accordance with the invention are administered to a subject with cancer in conjunction with other conventional cancer therapies such as radiation treatment or surgery. Radiation therapy is well-known in the art and includes X-ray therapies, such as gamma-irradiation, and radiopharmaceutical therapies.

In certain embodiments the inventive Mn₆ inhibitor compounds are used with at least one anti-cancer agent. Anti-cancer agents include chemotherapeutic drugs. A chemotherapeutic agent includes, but is not limited to, an inhibitor of chromatin function, a topoisomerase inhibitor, a microtubule inhibiting drug, a DNA damaging agent, an antimetabolite (such as folate antagonists, pyrimidine analogs, purine analogs, and sugar-modified analogs), a DNA synthesis inhibitor, a DNA interactive agent (such as an intercalating agent), and a DNA repair inhibitor.

Illustrative chemotherapeutic agents include, without limitation, the following groups: anti-metabolites/anti-cancer agents, such as pyrimidine analogs (5-fluorouracil, floxuridine, capecitabine, gemcitabine and cytarabine) and purine analogs, folate antagonists and related inhibitors (mercaptopurine, thioguanine, pentostatin and 2-chlorodeoxyadenosine (cladribine)); antiproliferative/antimitotic agents including natural products such as vinca alkaloids (vinblastine, vincristine, and vinorelbine), microtubule disruptors such as taxane (paclitaxel, docetaxel), vincristin, vinblastin, nocodazole, epothilones and navelbine, epipodophyllotoxins (etoposide, teniposide), DNA damaging agents (actinomycin, amsacrine, anthracyclines, bleomycin, busulfan, camptothecin, carboplatin, chlorambucil, cisplatin, cyclophosphamide, Cytoxan, dactinomycin, daunorubicin, doxorubicin, epirubicin, hexamethylmelamineoxaliplatin, iphosamide, melphalan, mechlorethamine, mitomycin, mitoxantrone, nitrosourea, plicamycin, procarbazine, taxol, taxotere, temozolamide, teniposide, triethylenethiophosphoramide and etoposide (VP 16)); antibiotics such as dactinomycin (actinomycin D), daunorubicin, doxorubicin (adriamycin), idarubicin, anthracyclines, mitoxantrone, bleomycins, plicamycin (mithramycin) and mitomycin; enzymes (L-asparaginase which systemically metabolizes L-asparagine and deprives cells which do not have the capacity to synthesize their own asparagine); antiplatelet agents; antiproliferative/antimitotic alkylating agents such as nitrogen mustards (mechlorethamine, cyclophosphamide and analogs, melphalan, chlorambucil), ethylenimines and methylmelamines (hexamethylmelamine and thiotepa), alkyl sulfonates-busulfan, nitrosoureas (carmustine (BCNU) and analogs, streptozocin), trazenes-dacarbazine (DTIC); antiproliferative/antimitotic antimetabolites such as folic acid analogs (methotrexate); platinum coordination complexes (cisplatin, carboplatin), procarbazine, hydroxyurea, mitotane, aminoglutethimide; hormones, hormone analogs (estrogen, tamoxifen, goserelin, bicalutamide, nilutamide) and aromatase inhibitors (letrozole, anastrozole); anticoagulants (heparin, synthetic heparin salts and other inhibitors of thrombin); fibrinolytic agents (such as tissue plasminogen activator, streptokinase and urokinase), aspirin, dipyridamole, ticlopidine, clopidogrel, abciximab; antimigratory agents; antisecretory agents (breveldin); immunosuppressives (cyclosporine, tacrolimus (FK-506), sirolimus (rapamycin), azathioprine, mycophenolate mofetil); anti-angiogenic compounds (TNP470, genistein) and growth factor inhibitors (vascular endothelial growth factor (VEGF) inhibitors, fibroblast growth factor (FGF)

inhibitors); angiotensin receptor blocker; nitric oxide donors; anti-sense oligonucleotides; antibodies (trastuzumab, rituximab); chimeric antigen receptors; cell cycle inhibitors and differentiation inducers (tretinoin); mTOR inhibitors, topoisomerase inhibitors (doxorubicin (adriamycin), amsacrine, camptothecin, daunorubicin, dactinomycin, eniposide, epirubicin, etoposide, idarubicin, irinotecan (CPT-11) and mitoxantrone, topotecan, irinotecan), corticosteroids (cortisone, dexamethasone, hydrocortisone, methylprednisolone, prednisone, and prenisolone); growth factor signal transduction kinase inhibitors; mitochondrial dysfunction inducers, toxins such as Cholera toxin, ricin, *Pseudomonas* exotoxin, *Bordetella pertussis* adenylate cyclase toxin, or diphtheria toxin, and caspase activators; and chromatin disruptors.

In certain embodiments an Mn₆ inhibitor in accordance with the present invention is used simultaneously, in the same formulation or in separate formulations, or sequentially with an additional agent(s) as part of a combination therapy regimen.

Mn₆ inhibitors according to Formula I and Formula II including their corresponding salts and pharmaceutical compositions of Formula I and Formula II compounds are also effective as therapeutic agents for treating or preventing cytokine mediated disorders, such as inflammation in a patient, preferably in a human. In one embodiment, a compound or composition in accordance with the invention is particularly useful for treating or preventing a disease selected from chronic or acute inflammation, chronic inflammatory arthritis, rheumatoid arthritis, psoriasis, COPD, inflammatory bowel disease, septic shock, Crohn's disease, ulcerative colitis, multiple sclerosis and asthma.

The inventive compounds their corresponding salts and pharmaceutically acceptable compositions are candidate therapeutics for treating brain related disorders which include without limitation autism, Fragile X-syndrome, Parkinson's disease and Alzheimer's disease. Treatment is effected by administering to a subject in need of treatment a Formula I or Formula II compound, its pharmaceutically acceptable salt form, or a pharmaceutically acceptable composition of a Formula I or Formula II compound or its salt.

In a further aspect of the invention the inventive compounds or pharmaceutically acceptable formulations of the inventive compounds are provided as inhibitors of Mn₆ activity. Such inhibition is achieved by contacting a cell expressing Mn₆ with a compound or a pharmaceutically acceptable formulation, to lower or inhibit Mn₆ activity, to provide therapeutic efficacy for a Mn₆ dependent condition in a mammal in need thereof.

Therapeutically effective dosages of a compound according to Formula I or Formula II or a composition of a Formula I or Formula II compound will generally range from about 1 to 2000 mg/day, from about 10 to about 1000 mg/day, from about 10 to about 500 mg/day, from about 10 to about 250 mg/day, from about 10 to about 100 mg/day, or from about 10 to about 50 mg/day. The therapeutically effective dosages may be administered in one or multiple doses. It will be appreciated, however, that specific doses of the compounds of the invention for any particular patient will depend on a variety of factors such as age, sex, body weight, general health condition, diet, individual response of the patient to be treated, time of administration, severity of the disease to be treated, the activity of particular compound applied, dosage form, mode of application and concomitant medication. The therapeutically effective amount for a given situation will readily be determined by routine experimentation and is within the skills and judgment of the ordinary

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clinician or physician. In any case the compound or composition will be administered at dosages and in a manner which allows a therapeutically effective amount to be delivered based upon patient's unique condition.

EXAMPLES

In the synthetic schemes described below, unless otherwise indicated all temperatures are set forth in degrees Celsius and all parts and percentages are by weight. Reagents are purchased from commercial suppliers and are used without further purification unless otherwise indicated. All solvents are purchased from commercial suppliers and are used as received.

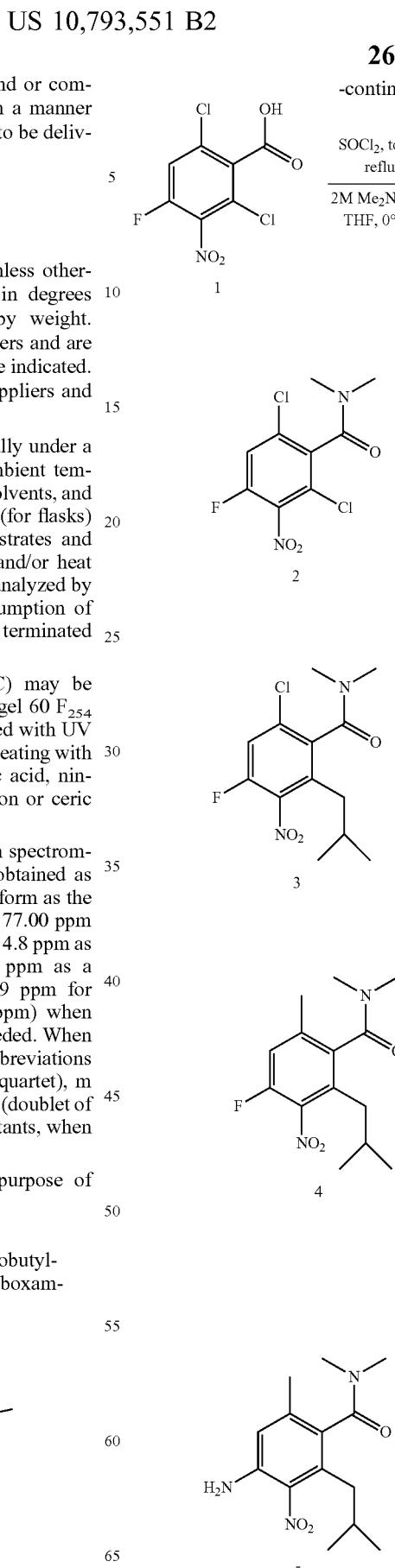
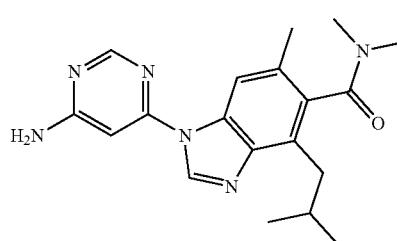
The reactions set forth below are done generally under a positive pressure of nitrogen or argon at an ambient temperature (unless otherwise stated) in anhydrous solvents, and the reaction vessels are fitted with rubber septa (for flasks) or caps (for vials) for the introduction of substrates and reagents via syringe. Glassware is oven dried and/or heat dried. The reactions are assayed by TLC and/or analyzed by LC-MS and terminated as judged by the consumption of starting material. Occasionally, reactions are terminated early as desired products start to decompose.

Analytical thin layer chromatography (TLC) may be performed on glass-plates precoated with silica gel 60 F_{254} 0.25 mm plates (EMD Chemicals), and visualized with UV light (254 nm) and/or iodine on silica gel and/or heating with TLC stains such as ethanolic phosphomolybdc acid, ninhydrin solution, potassium permanganate solution or ceric sulfate solution.

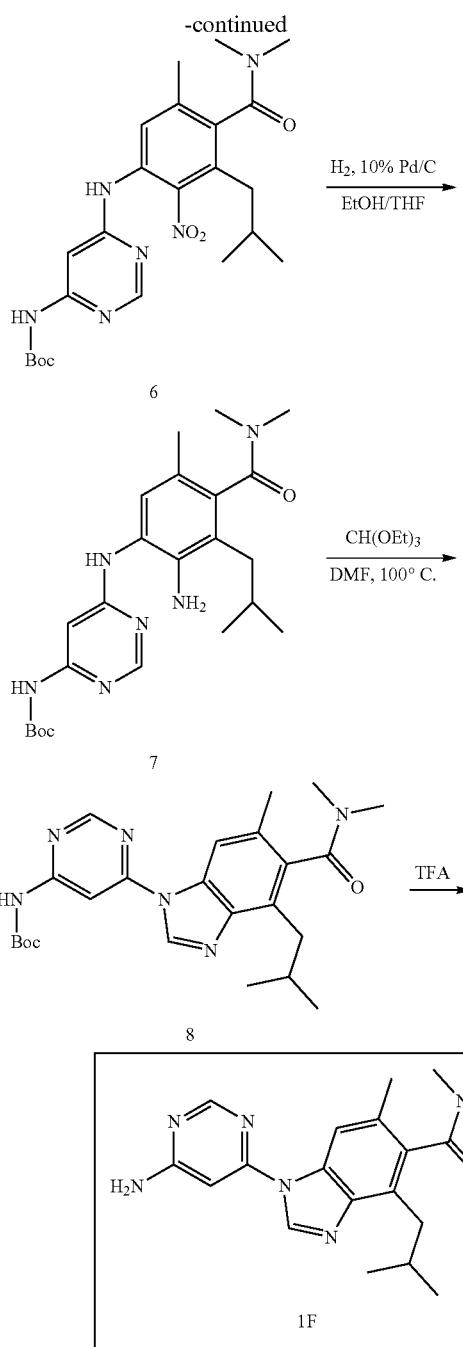
$^1\text{H-NMR}$ spectra may be recorded on a Varian spectrometer operating at 400 MHz. NMR spectra are obtained as CDCl_3 solutions (reported in ppm), using chloroform as the reference standard (7.27 ppm for the proton and 77.00 ppm for carbon), CD_3OD solutions using 3.4 ppm and 4.8 ppm as reference standards for the protons and 49.3 ppm as a reference standard for carbon, DMSO-d_6 (2.49 ppm for proton), or internally tetramethylsilane (0.00 ppm) when appropriate. Other NMR solvents are used as needed. When peak multiplicities are reported, the following abbreviations are used: s (singlet), d (doublet), t (triplet), q (quartet), m (multiplet), br (broadened), bs (broad singlet), dd (doublet of doublets), dt (doublet of triplets). Coupling constants, when given, are reported in Hertz (Hz).

The following examples are provided for purpose of illustration only.

Example 1: 1-(6-Aminopyrimidin-4-yl)-4-isobutyl-N,N,6-trimethyl-1H-benzo[d]imidazole-5-carboxamide (Cpd. No. 1F)



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Synthesis of 2,6-dichloro-4-fluoro-N,N-dimethyl-3-nitrobenzamide (2)

To a stirred solution of 2,6-dichloro-4-fluoro-3-nitrobenzoic acid (1, 1 g, 3.94 mmol) in toluene (10 mL) is added thionyl chloride (10 mL) slowly. The reaction is stirred at reflux for 2 h. The resulting mixture is cooled to room temperature, concentrated and dried under vacuum.

To a solution of the above crude in tetrahydrofuran at 0°C. is added 2 M dimethylamine in tetrahydrofuran (7.88 mL, 15.76 mmol). The reaction is stirred at room temperature for 1 h. The resulting mixture is diluted with ethyl acetate and washed with water. The organic layer is dried over magnesium sulfate, filtered and concentrated. The crude is purified

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via column chromatography to afford 2,6-dichloro-4-fluoro-N,N-dimethyl-3-nitrobenzamide (2).

Synthesis of 6-chloro-4-fluoro-2-isobutyl-N,N-dimethyl-3-nitrobenzamide (3)

A mixture of 2,6-dichloro-4-fluoro-N,N-dimethyl-3-nitrobenzamide (2, 1 g, 3.56 mmol), trifluoro(isobutyl)- λ^4 -borane, potassium salt (2a, 1.17 g, 7.12 mmol) and cesium carbonate (3.48 g, 10.68 mmol) in tetrahydrofuran (20 mL) and water (5 mL) is purged with argon for 5 min. [1,1'-Bis(diphenylphosphino)ferrocene]dichloropalladium(II), complex with dichloromethane (0.29 g, 0.36 mmol) is added and the mixture is purged with argon for another 5 min. The reaction is sealed and stirred at 80°C. overnight. The resulting mixture is cooled to room temperature and filtered through a pad of celite. The filtrate is diluted with ethyl acetate and washed with water. The organic layer is dried over magnesium sulfate, filtered and concentrated. The crude is purified via column chromatography to afford 6-chloro-4-fluoro-2-isobutyl-N,N-dimethyl-3-nitrobenzamide (3).

Synthesis of 4-fluoro-2-isobutyl-N,N,6-trimethyl-3-nitrobenzamide (4)

A mixture of 6-chloro-4-fluoro-2-isobutyl-N,N-dimethyl-3-nitrobenzamide (3, 1.08 g, 3.56 mmol), trifluoro(methyl)- λ^4 -borane, potassium salt (3a, 1.17 g, 7.12 mmol) and cesium carbonate (3.48 g, 10.68 mmol) in tetrahydrofuran (20 mL) and water (5 mL) is purged with argon for 5 min. [1,1'-Bis(diphenylphosphino)ferrocene]dichloropalladium (II), complex with dichloromethane (0.29 g, 0.36 mmol) is added and the mixture is purged with argon for another 5 min. The reaction is sealed and stirred at 80°C. overnight. The resulting mixture is cooled to room temperature and filtered through a pad of celite. The filtrate is diluted with ethyl acetate and washed with water. The organic layer is dried over magnesium sulfate, filtered and concentrated. The crude is purified via column chromatography to afford 4-fluoro-2-isobutyl-N,N,6-trimethyl-3-nitrobenzamide (4).

Synthesis of 4-amino-2-isobutyl-N,N,6-trimethyl-3-nitrobenzamide (5)

To a solution of 4-fluoro-2-isobutyl-N,N,6-trimethyl-3-nitrobenzamide (4, 1 g, 3.54 mmol) in tetrahydrofuran (20 mL) is added ammonium hydroxide (5 mL). The reaction is stirred at 60°C. overnight. The resulting mixture is cooled to room temperature, diluted with ethyl acetate and washed with water. The organic layer is dried over magnesium sulfate, filtered and concentrated. The crude is purified via column chromatography to afford 4-amino-2-isobutyl-N,N,6-trimethyl-3-nitrobenzamide (5).

Synthesis of tert-butyl (6-((4-(dimethylcarbamoyl)-3-isobutyl-5-methyl-2-nitrophenyl)amino)pyrimidin-4-yl)carbamate (6)

A mixture of 4-amino-2-isobutyl-N,N,6-trimethyl-3-nitrobenzamide (5, 1 g, 3.58 mmol), tert-butyl (6-chloropyrimidin-4-yl)carbamate (5a, 0.82 g, 3.58 mmol) and cesium carbonate (3.50 g, 10.74 mmol) in dioxane (20 mL) is purged with argon for 5 min. XantPhos (0.42 g, 0.72 mmol) and tris(dibenzylideneacetone)dipalladium(0) (0.33 g, 0.36 mmol) are added and the mixture is purged with argon for another 5 min. The reaction is sealed and stirred at 90°C.

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overnight. The resulting mixture is cooled to room temperature and filtered through a pad of celite. The filtrate is diluted with ethyl acetate and washed with water. The organic layer is dried over magnesium sulfate, filtered and concentrated. The crude is purified via column chromatography to afford tert-butyl (6-((4-(dimethylcarbamoyl)-3-isobutyl-5-methyl-2-nitrophenyl)amino)pyrimidin-4-yl)carbamate (6).

Synthesis of tert-butyl (6-((2-amino-4-(dimethylcarbamoyl)-3-isobutyl-5-methylphenyl)amino)pyrimidin-4-yl)carbamate (7)

To a solution of tert-butyl (6-((4-(dimethylcarbamoyl)-3-isobutyl-5-methyl-2-nitrophenyl)amino)pyrimidin-4-yl)carbamate (6, 1 g, 2.12 mmol) in ethanol (10 mL) and tetrahydrofuran (10 mL) is added 10% palladium on carbon (100 mg). The mixture is purged with hydrogen and stirred under hydrogen atmosphere overnight. The resulting mixture is filtered through a pad of celite and concentrated. The crude is purified via column chromatography to afford tert-butyl (6-((2-amino-4-(dimethylcarbamoyl)-3-isobutyl-5-methyl-phenyl)amino)pyrimidin-4-yl)carbamate (7).

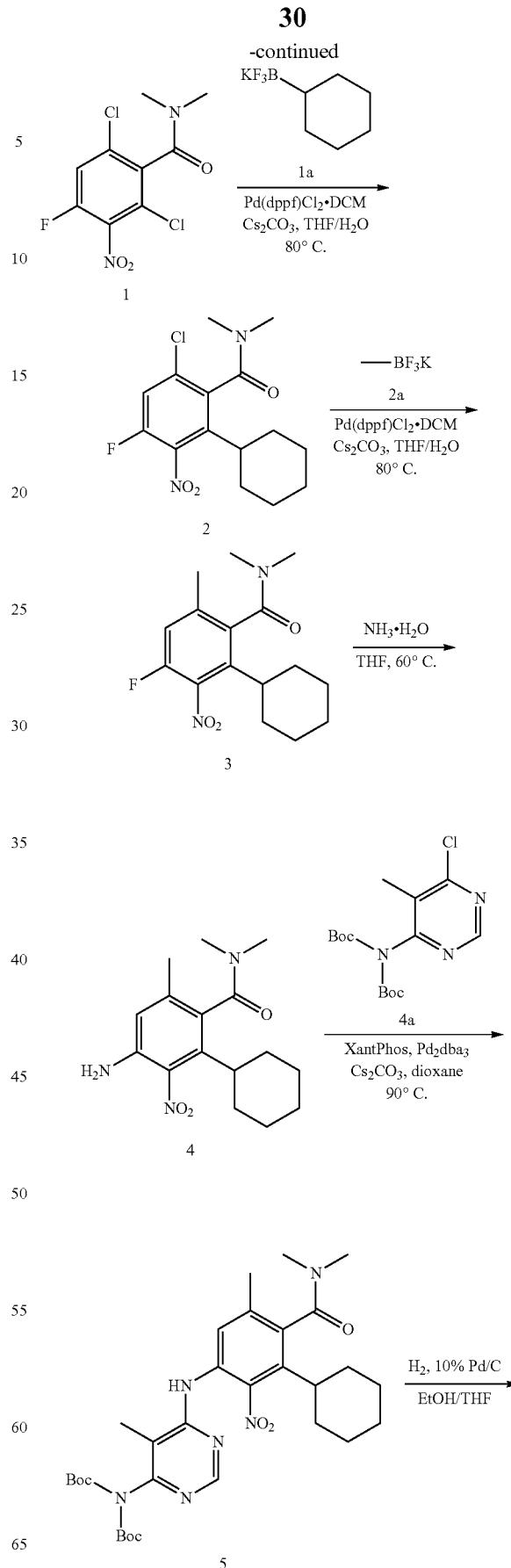
Synthesis of tert-butyl (6-(5-(dimethylcarbamoyl)-4-isobutyl-6-methyl-1H-benzo[d]imidazol-1-yl)pyrimidin-4-yl)carbamate (8)

To a solution of tert-butyl (6-((2-amino-4-(dimethylcarbamoyl)-3-isobutyl-5-methylphenyl)amino)pyrimidin-4-yl) carbamate (7, 1 g, 2.26 mmol) in N,N-dimethylformamide (20 mL) is added triethyl orthoformate (0.75 mL, 4.52 mmol). The reaction is stirred at 100° C. overnight. The resulting mixture is cooled to room temperature, diluted with ethyl acetate and washed with water. The organic layer is dried over magnesium sulfate, filtered and concentrated. The crude is purified via column chromatography to afford tert-butyl (6-(5-(dimethylcarbamoyl)-4-isobutyl-6-methyl-1H-benzo[d]imidazol-1-yl)pyrimidin-4-yl)carbamate (8).

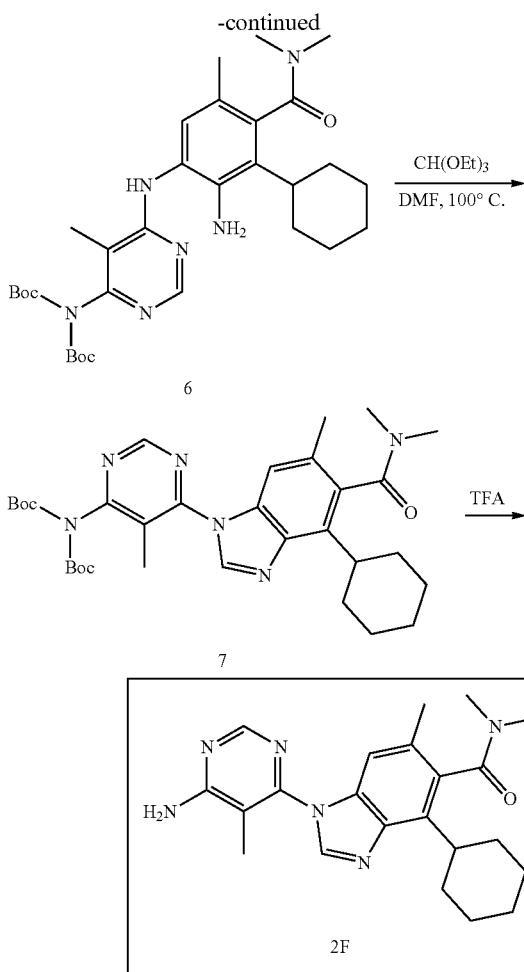
Synthesis of 1-(6-aminopyrimidin-4-yl)-4-isobutyl-N,N, 6-trimethyl-1H-benzo[d]imidazole-5-carboxamide (Cpd. No. 1F)

tert-Butyl (6-(5-(dimethylcarbamoyl)-4-isobutyl-6-methyl-1H-benzo[d]imidazol-1-yl)pyrimidin-4-yl)carbamate (8, 1 g, 2.21 mmol) is dissolved in trifluoroacetic acid (10 mL). The reaction is stirred at room temperature overnight. The resulting mixture is concentrated and purified via reversed phase HPLC to afford 1-(6-aminopyrimidin-4-yl)-4-isobutyl-N,N,6-trimethyl-1H-benzo[d]imidazole-5-carboxamide (Cpd. No. 1F) as a trifluoroacetic acid salt. 45 50

Example 2: 1-(6-amino-5-methylpyrimidin-4-yl)-4-cyclohexyl-N,N,6-trimethyl-1H-benzo[d]imidazole-5-carboxamide (Cpd. No. 2F)



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Synthesis of 6-chloro-2-cyclohexyl-4-fluoro-N,N-dimethyl-3-nitrobenzamide (2)

A mixture of 2,6-dichloro-4-fluoro-N,N-dimethyl-3-nitrobenzamide (1, 1 g, 3.56 mmol), cyclohexyltrifluoro-14-borane, potassium salt (1a, 1.35 g, 7.12 mmol) and cesium carbonate (3.48 g, 10.68 mmol) in tetrahydrofuran (20 mL) and water (5 mL) is purged with argon for 5 min. [1,1'-Bis (diphenylphosphino)ferrocene]dichloropalladium(II), complex with dichloromethane (0.29 g, 0.36 mmol) is added and the mixture is purged with argon for another 5 min. The reaction is sealed and stirred at 80° C. overnight. The resulting mixture is cooled to room temperature and filtered through a pad of celite. The filtrate is diluted with ethyl acetate and washed with water. The organic layer is dried over magnesium sulfate, filtered and concentrated. The crude is purified via column chromatography to afford 6-chloro-2-cyclohexyl-4-fluoro-N,N-dimethyl-3-nitrobenzamide (2).

Synthesis of 2-cyclohexyl-4-fluoro-N,N,6-trimethyl-3-nitrobenzamide (3)

A mixture of 6-chloro-2-cyclohexyl-4-fluoro-N,N-dimethyl-3-nitrobenzamide (2, 1.08 g, 3.56 mmol), trifluoro(methyl)-λ⁴-borane, potassium salt (2a, 1.17 g, 7.12 mmol) and cesium carbonate (3.48 g, 10.68 mmol) in tetrahydrofuran (20 mL) and water (5 mL) is purged with argon for 5

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min. [1,1'-Bis(diphenylphosphino)ferrocene]dichloropalladium(II), complex with dichloromethane (0.29 g, 0.36 mmol) is added and the mixture is purged with argon for another 5 min. The reaction is sealed and stirred at 80° C. overnight. The resulting mixture is cooled to room temperature and filtered through a pad of celite. The filtrate is diluted with ethyl acetate and washed with water. The organic layer is dried over magnesium sulfate, filtered and concentrated. The crude is purified via column chromatography to afford 2-cyclohexyl-4-fluoro-N,N,6-trimethyl-3-nitrobenzamide (3).

Synthesis of 4-amino-2-cyclohexyl-N,N,6-trimethyl-3-nitrobenzamide (4)

To a solution of 2-cyclohexyl-4-fluoro-N,N,6-trimethyl-3-nitrobenzamide (3, 1 g, 3.24 mmol) in tetrahydrofuran (20 mL) is added ammonium hydroxide (5 mL). The reaction is stirred at 60° C. overnight. The resulting mixture is cooled to room temperature, diluted with ethyl acetate and washed with water. The organic layer is dried over magnesium sulfate, filtered and concentrated. The crude is purified via column chromatography to afford 4-amino-2-cyclohexyl-N,N,6-trimethyl-3-nitrobenzamide (4).

Synthesis of tert-butyl N-tert-butoxycarbonyl-N-(6-((3-cyclohexyl-4-(dimethylcarbamoyl)-5-methyl-2-nitrophenyl)amino)-5-methylpyrimidin-4-yl)carbamate (5)

A mixture of 4-amino-2-cyclohexyl-N,N,6-trimethyl-3-nitrobenzamide (4, 1.09 g, 3.58 mmol), tert-butyl N-tert-butoxycarbonyl-N-(6-chloro-5-methyl-pyrimidin-4-yl)carbamate (4a, 1.23 g, 3.58 mmol) and cesium carbonate (3.50 g, 10.74 mmol) in dioxane (20 mL) is purged with argon for 5 min. XantPhos (0.42 g, 0.72 mmol) and tris(dibenzylideneacetone)dipalladium(0) (0.33 g, 0.36 mmol) are added and the mixture is purged with argon for another 5 min. The reaction is sealed and stirred at 90° C. overnight. The resulting mixture is cooled to room temperature and filtered through a pad of celite. The filtrate is diluted with ethyl acetate and washed with water. The organic layer is dried over magnesium sulfate, filtered and concentrated. The crude is purified via column chromatography to afford tert-butyl N-tert-butoxycarbonyl-N-(6-((3-cyclohexyl-4-(dimethylcarbamoyl)-5-methyl-2-nitrophenyl)amino)-5-methylpyrimidin-4-yl)carbamate (5).

Synthesis of tert-butyl N-tert-butoxycarbonyl-N-(6-((2-amino-3-cyclohexyl-4-(dimethylcarbamoyl)-5-methylphenyl)amino)-5-methylpyrimidin-4-yl)carbamate (6)

To a solution of tert-butyl N-tert-butoxycarbonyl-N-(6-((3-cyclohexyl-4-(dimethylcarbamoyl)-5-methyl-2-nitrophenyl)amino)-5-methylpyrimidin-4-yl)carbamate (5, 1 g, 1.63 mmol) in ethanol (10 mL) and tetrahydrofuran (10 mL) is added 10% palladium on carbon (100 mg). The mixture is purged with hydrogen and stirred under hydrogen atmosphere overnight. The resulting mixture is filtered through a pad of celite and concentrated. The crude is purified via column chromatography to afford tert-butyl N-tert-butoxycarbonyl-N-(6-((2-amino-3-cyclohexyl-4-(dimethylcarbamoyl)-5-methylphenyl)amino)-5-methylpyrimidin-4-yl)carbamate (6).

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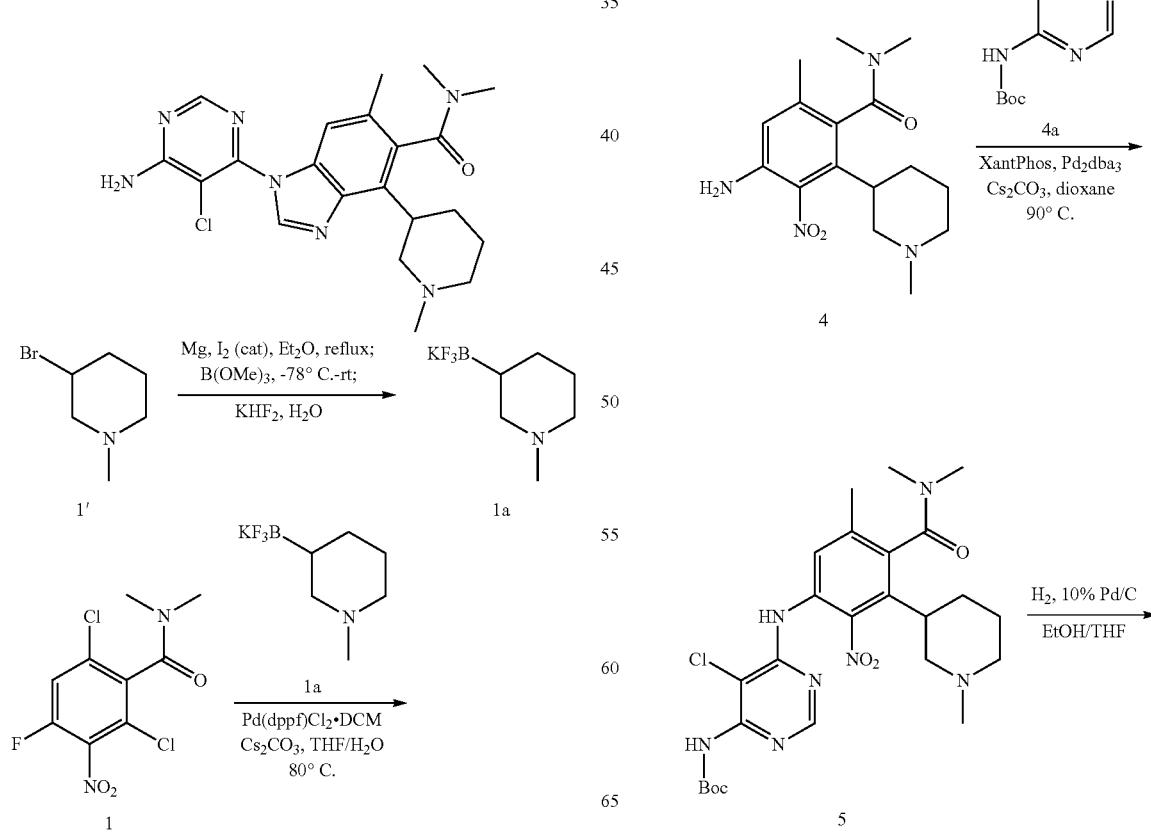
Synthesis of tert-butyl N-tert-butoxycarbonyl-N-(6-(4-cyclohexyl-5-(dimethylcarbamoyl)-6-methyl-1H-benzo[d]imidazol-1-yl)-5-methylpyrimidin-4-yl)carbamate (7)

To a solution of tert-butyl N-tert-butoxycarbonyl-N-(6-(2-amino-3-cyclohexyl-4-(dimethylcarbamoyl)-5-methylphenyl)amino)-5-methylpyrimidin-4-yl)carbamate (6, 1.32 g, 2.26 mmol) in N,N-dimethylformamide (20 mL) is added triethyl orthoformate (0.75 mL, 4.52 mmol). The reaction is stirred at 100° C. overnight. The resulting mixture is cooled to room temperature, diluted with ethyl acetate and washed with water. The organic layer is dried over magnesium sulfate, filtered and concentrated. The crude is purified via column chromatography to afford tert-butyl N-tert-butoxycarbonyl-N-(6-(4-cyclohexyl-5-(dimethylcarbamoyl)-6-methyl-1H-benzo[d]imidazol-1-yl)-5-methylpyrimidin-4-yl)carbamate (7).

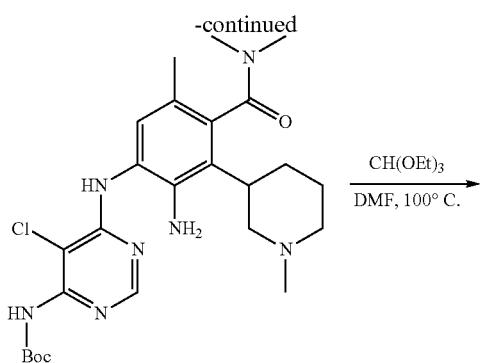
Synthesis of 1-(6-amino-5-methylpyrimidin-4-yl)-4-cyclohexyl-N,N, 6-trimethyl-1H-benzo[d]imidazole-5-carboxamide (Cpd. No. 2F)

tert-Butyl N-tert-butoxycarbonyl-N-(6-(4-cyclohexyl-5-(dimethylcarbamoyl)-6-methyl-1H-benzo[d]imidazol-1-yl)-5-methylpyrimidin-4-yl)carbamate (7, 1 g, 1.69 mmol) is dissolved in trifluoroacetic acid (10 mL). The reaction is stirred at room temperature overnight. The resulting mixture is concentrated and purified via reversed phase HPLC to afford 1-(6-amino-5-methylpyrimidin-4-yl)-4-cyclohexyl-N,N,6-trimethyl-1H-benzo[d]imidazole-5-carboxamide (Cpd. No. 2F) as a trifluoroacetic acid salt.

Example 3: 1-(6-amino-5-chloropyrimidin-4-yl)-N,N,6-trimethyl-4-(1-methylpiperidin-3-yl)-1H-benzo[d]imidazole-5-carboxamide (Cpd. No. 3F)



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Synthesis of 1-methyl-3-(trifluoro- λ^4 -boraneyl)piperidine, potassium salt (1a)

To a mixture of 3-bromo-1-methylpiperidine (1', 1 g, 5.62 mmol) and magnesium turnings (1.37 g, 56.2 mmol) in ethyl ether (20 mL) is added iodine (71 mg, 0.28 mmol). The reaction is stirred at room temperature for 1 h, then at reflux overnight. The resulting mixture is added to trimethylborate (0.94 mL, 8.43 mmol) at -78°C . The reaction is stirred at room temperature for 2 h. An aqueous solution of potassium hydrogen difluoride (2.19 g, 28.1 mmol, 6 mL) is added dropwise to the above mixture. The reaction is stirred at room temperature overnight. The resulting mixture is concentrated, re-dissolved in hot acetone and filtered. The filtrate is concentrated and triturated with ethyl ether. The solid is recrystallized with acetone, methanol and ethyl ether to afford 1-methyl-3-(trifluoro- λ^4 -boraneyl)piperidine, potassium salt (1a).

Synthesis of 6-chloro-4-fluoro-N,N-dimethyl-2-(1-methylpiperidin-3-yl)-3-nitrobenzamide (2)

A mixture of 2,6-dichloro-4-fluoro-N,N-dimethyl-3-nitrobenzamide (1, 1 g, 3.56 mmol), 1-methyl-3-(trifluoro- λ^4 -boraneyl)piperidine, potassium salt (1a, 1.46 g, 7.12 mmol)

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and cesium carbonate (3.48 g, 10.68 mmol) in tetrahydrofuran (20 mL) and water (5 mL) is purged with argon for 5 min. [1,1'-Bis(diphenylphosphino)ferrocene]dichloropalladium(II), complex with dichloromethane (0.29 g, 0.36 mmol) is added and the mixture is purged with argon for another 5 min. The reaction is sealed and stirred at 80°C . overnight. The resulting mixture is cooled to room temperature and filtered through a pad of celite. The filtrate is diluted with ethyl acetate and washed with water. The organic layer is dried over magnesium sulfate, filtered and concentrated. The crude is purified via column chromatography to afford 6-chloro-4-fluoro-N,N-dimethyl-2-(1-methylpiperidin-3-yl)-3-nitrobenzamide (2).

15 Synthesis of 4-fluoro-N,N,6-trimethyl-2-(1-methylpiperidin-3-yl)-3-nitrobenzamide (3)

A mixture of 6-chloro-4-fluoro-N,N-dimethyl-2-(1-methylpiperidin-3-yl)-3-nitrobenzamide (2, 1.22 g, 3.56 mmol), trifluoro(methyl)- λ^4 -borane, potassium salt (2a, 1.17 g, 7.12 mmol) and cesium carbonate (3.48 g, 10.68 mmol) in tetrahydrofuran (20 mL) and water (5 mL) is purged with argon for 5 min. [1,1'-Bis(diphenylphosphino)ferrocene]dichloropalladium(II), complex with dichloromethane (0.29 g, 0.36 mmol) is added and the mixture is purged with argon for another 5 min. The reaction is sealed and stirred at 80°C . overnight. The resulting mixture is cooled to room temperature and filtered through a pad of celite. The filtrate is diluted with ethyl acetate and washed with water. The organic layer is dried over magnesium sulfate, filtered and concentrated. The crude is purified via column chromatography to afford 4-fluoro-N,N,6-trimethyl-2-(1-methylpiperidin-3-yl)-3-nitrobenzamide (3).

35 Synthesis of 4-amino-N,N,6-trimethyl-2-(1-methylpiperidin-3-yl)-3-nitrobenzamide (4)

To a solution of 4-fluoro-N,N,6-trimethyl-2-(1-methylpiperidin-3-yl)-3-nitrobenzamide (3, 1 g, 3.09 mmol) in tetrahydrofuran (20 mL) is added ammonium hydroxide (5 mL). The reaction is stirred at 60°C . overnight. The resulting mixture is cooled to room temperature, diluted with ethyl acetate and washed with water. The organic layer is dried over magnesium sulfate, filtered and concentrated. The crude is purified via column chromatography to afford 4-amino-N,N,6-trimethyl-2-(1-methylpiperidin-3-yl)-3-nitrobenzamide (4).

50 Synthesis of tert-butyl (5-chloro-6-((4-(dimethylcarbamoyl)-5-methyl-3-(1-methylpiperidin-3-yl)-2-nitrophenyl)amino)pyrimidin-4-yl)carbamate (5)

A mixture of 4-amino-N,N,6-trimethyl-2-(1-methylpiperidin-3-yl)-3-nitrobenzamide (4, 1.15 g, 3.58 mmol), tert-butyl (5,6-dichloropyrimidin-4-yl)carbamate (4a, 0.94 g, 3.58 mmol) and cesium carbonate (3.50 g, 10.74 mmol) in dioxane (20 mL) is purged with argon for 5 min. XantPhos (0.42 g, 0.72 mmol) and tris(dibenzylideneacetone)dipalladium(0) (0.33 g, 0.36 mmol) are added and the mixture is purged with argon for another 5 min. The reaction is sealed and stirred at 90°C . overnight. The resulting mixture is cooled to room temperature and filtered through a pad of celite. The filtrate is diluted with ethyl acetate and washed with water. The organic layer is dried over magnesium sulfate, filtered and concentrated. The crude is purified via column chromatography to afford tert-butyl (5-chloro-6-((4-

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(dimethylcarbamoyl)-5-methyl-3-(1-methylpiperidin-3-yl)-2-nitrophenyl)amino)pyrimidin-4-yl)carbamate (5).

Synthesis of tert-butyl (6-((2-amino-4-(dimethylcarbamoyl)-5-methyl-3-(1-methylpiperidin-3-yl)phenyl)amino)-5-chloropyrimidin-4-yl)carbamate (6)

To a solution of tert-butyl (5-chloro-6-((4-(dimethylcarbamoyl)-5-methyl-3-(1-methylpiperidin-3-yl)2-nitrophenyl)amino)pyrimidin-4-yl)carbamate (5, 1 g, 1.82 mmol) in ethanol (10 mL) and tetrahydrofuran (10 mL) is added 10% palladium on carbon (100 mg). The mixture is purged with hydrogen and stirred under hydrogen atmosphere overnight. The resulting mixture is filtered through a pad of celite and concentrated. The crude is purified via column chromatography to afford tert-butyl (6-((2-amino-4-(dimethylcarbamoyl)-5-methyl-3-(1-methylpiperidin-3-yl)phenyl)amino)-5-chloropyrimidin-4-yl)carbamate (6).

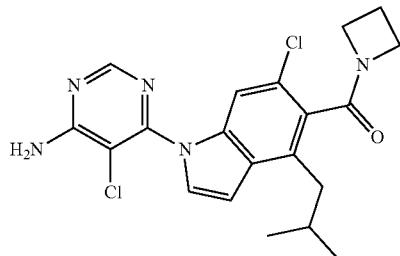
Synthesis of tert-butyl (5-chloro-6-(5-(dimethylcarbamoyl)-6-methyl-4-(1-methylpiperidin-3-yl)-1H-benzo[d]imidazol-1-yl)pyrimidin-4-yl)carbamate (7)

To a solution of tert-butyl (6-((2-amino-4-(dimethylcarbamoyl)-5-methyl-3-(1-methylpiperidin-3-yl)phenyl)amino)-5-chloropyrimidin-4-yl)carbamate (6, 1.17 g, 2.26 mmol) in N,N-dimethylformamide (20 mL) is added triethyl orthoformate (0.75 mL, 4.52 mmol). The reaction is stirred at 100° C. overnight. The resulting mixture is cooled to room temperature, diluted with ethyl acetate and washed with water. The organic layer is dried over magnesium sulfate, filtered and concentrated. The crude is purified via column chromatography to afford tert-butyl (5-chloro-6-(5-(dimethylcarbamoyl)-6-methyl-4-(1-methylpiperidin-3-yl)-1H-benzo[d]imidazol-1-yl)pyrimidin-4-yl)carbamate (7).

Synthesis of 1-(6-amino-5-chloropyrimidin-4-yl)-N,N,6-trimethyl-4-(1-methylpiperidin-3-yl)-1H-benzo[d]imidazole-5-carboxamide (Cpd. No. 3F)

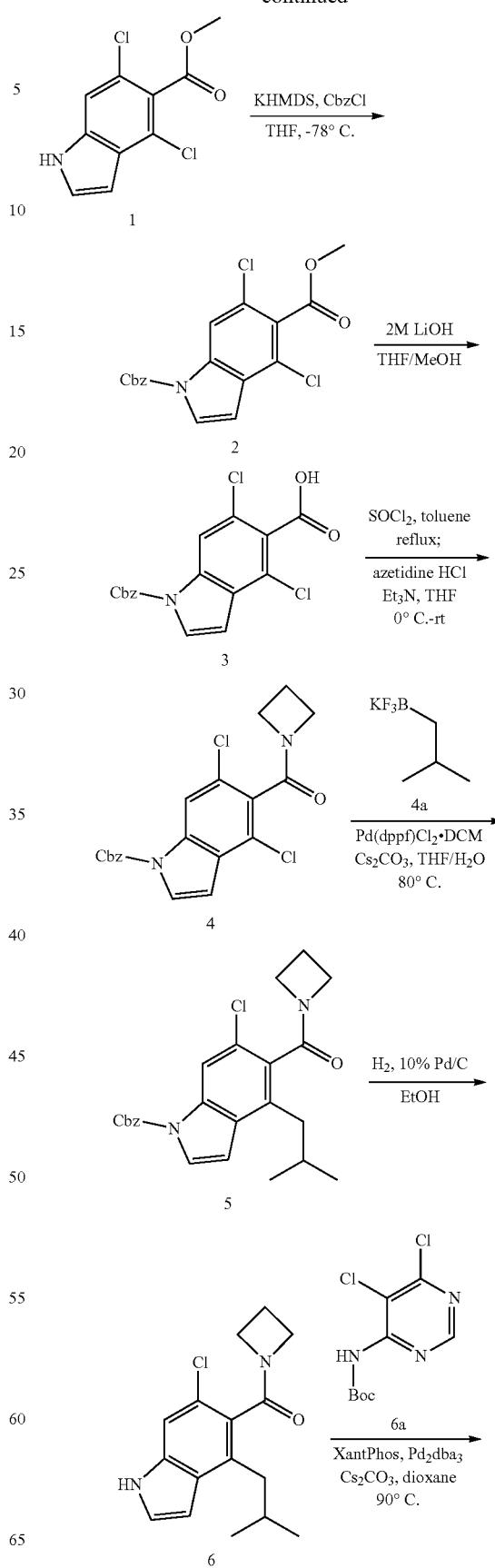
tert-Butyl (5-chloro-6-(5-(dimethylcarbamoyl)-6-methyl-4-(1-methylpiperidin-3-yl)-1H-benzo[d]imidazol-1-yl)pyrimidin-4-yl)carbamate (7, 1 g, 1.89 mmol) is dissolved in trifluoroacetic acid (10 mL). The reaction is stirred at room temperature overnight. The resulting mixture is concentrated and purified via reversed phase HPLC to afford 1-(6-amino-5-chloropyrimidin-4-yl)-N,N,6-trimethyl-4-(1-methylpiperidin-3-yl)-1H-benzo[d]imidazole-5-carboxamide (Cpd. No. 3F) as a trifluoroacetic acid salt.

Example 4: (1-(6-amino-5-chloropyrimidin-4-yl)-6-chloro-4-isobutyl-1H-indol-5-yl)(azetidin-1-yl) methanone (Cpd. No. 4F)



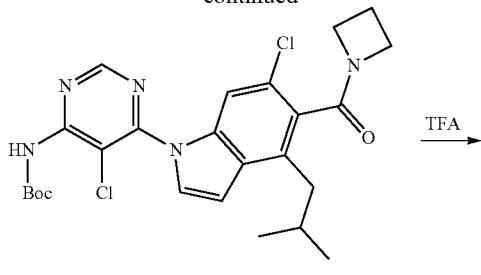
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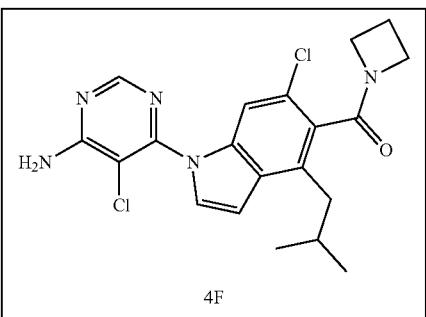


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Synthesis of 1-benzyl 5-methyl 4,6-dichloro-1H-indole-1,5-dicarboxylate (2)

To a solution of methyl 4,6-dichloro-1H-indole-5-carboxylate (1, 1 g, 4.10 mmol) in tetrahydrofuran (40 mL) at -78°C. is added dropwise 1 M potassium bis(trimethylsilyl)amide in tetrahydrofuran (4.92 mL, 4.92 mmol). The reaction is stirred at -78°C. for 30 min, then benzyl chloroformate (1.17 mL, 8.20 mmol) is added dropwise. The reaction is stirred at -78°C. for 4 h before it is quenched with 1 M hydrochloric acid. The resulting mixture is warmed to room temperature and extracted with ethyl acetate. The organic layer is dried over magnesium sulfate, filtered and concentrated. The crude is purified via column chromatography to afford 1-benzyl 5-methyl 4,6-dichloro-1H-indole-1,5-dicarboxylate (2).

Synthesis of 1-((benzyloxy)carbonyl)-4,6-dichloro-1H-indole-5-carboxylic acid (3)

To a solution of 1-benzyl 5-methyl 4,6-dichloro-1H-indole-1,5-dicarboxylate (2) in tetrahydrofuran and methanol is added 2 M aqueous solution of lithium hydroxide. The reaction is stirred at room temperature overnight before it is quenched with the addition of 1 M hydrochloric acid. The resulting mixture is warmed to room temperature and extracted with ethyl acetate. The organic layer is dried over magnesium sulfate, filtered and concentrated. The crude is purified via column chromatography to afford 1-((benzyloxy)carbonyl)-4,6-dichloro-1H-indole-5-carboxylic acid (3).

Synthesis of benzyl 5-(azetidine-1-carbonyl)-4,6-dichloro-1H-indole-1-carboxylate (4)

To a stirred solution of 1-((benzyloxy)carbonyl)-4,6-dichloro-1H-indole-5-carboxylic acid (3, 1 g, 3.94 mmol) in toluene (10 mL) is added thionyl chloride (10 mL) slowly. The reaction is stirred at reflux for 2 h. The resulting mixture is cooled to room temperature, concentrated and dried under vacuum.

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To a solution of the above crude in tetrahydrofuran at 0°C. is added trimethylamine (5.49 mL, 39.4 mmol) and azetidine hydrochloride (1.47 g, 15.76 mmol). The reaction is stirred at room temperature for 1 h. The resulting mixture is diluted with ethyl acetate and washed with water. The organic layer is dried over magnesium sulfate, filtered and concentrated. The crude is purified via column chromatography to afford 2,6-dichloro-4-fluoro-N,N-dimethyl-3-nitrobenzamide (4).

10 Synthesis of benzyl 5-(azetidine-1-carbonyl)-6-chloro-4-isobutyl-1H-indole-1-carboxylate (5)

A mixture of 2,6-dichloro-4-fluoro-N,N-dimethyl-3-nitrobenzamide (4, 1.44 g, 3.56 mmol), trifluoro(isobutyl)- λ^4 -borane, potassium salt (4a, 1.17 g, 7.12 mmol) and cesium carbonate (3.48 g, 10.68 mmol) in tetrahydrofuran (20 mL) and water (5 mL) is purged with argon for 5 min. [1,1'-Bis(diphenylphosphino)ferrocene]dichloropalladium(II), complex with dichloromethane (0.29 g, 0.36 mmol) is added and the mixture is purged with argon for another 5 min. The reaction is sealed and stirred at 80°C. overnight. The resulting mixture is cooled to room temperature and filtered through a pad of celite. The filtrate is diluted with ethyl acetate and washed with water. The organic layer is dried over magnesium sulfate, filtered and concentrated. The crude is purified via column chromatography to afford benzyl 5-(azetidine-1-carbonyl)-6-chloro-4-isobutyl-1H-indole-1-carboxylate (5).

30 Synthesis of azetidin-1-yl(6-chloro-4-isobutyl-1H-indol-5-yl)methanone (6)

To a solution of benzyl 5-(azetidine-1-carbonyl)-6-chloro-4-isobutyl-1H-indole-1-carboxylate (5, 1 g, 2.35 mmol) in ethanol (20 mL) is added 10% palladium on carbon (100 mg). The mixture is purged with hydrogen and stirred under hydrogen atmosphere overnight. The resulting mixture is filtered through a pad of celite and concentrated. The crude is purified via column chromatography to afford azetidin-1-yl(6-chloro-4-isobutyl-1H-indol-5-yl)methanone (6).

45 Synthesis of tert-butyl (6-(5-(azetidine-1-carbonyl)-6-chloro-4-isobutyl-1H-indol-1-yl)-5-chloropyrimidin-4-yl)carbamate (7)

A mixture of azetidin-1-yl(6-chloro-4-isobutyl-1H-indol-5-yl)methanone (6, 1.04 g, 3.58 mmol), tert-butyl (5,6-dichloropyrimidin-4-yl)carbamate (6a, 0.94 g, 3.58 mmol) and cesium carbonate (3.50 g, 10.74 mmol) in dioxane (20 mL) is purged with argon for 5 min. XantPhos (0.42 g, 0.72 mmol) and tris(dibenzylideneacetone)dipalladium(0) (0.33 g, 0.36 mmol) are added and the mixture is purged with argon for another 5 min. The reaction is sealed and stirred at 90°C. overnight. The resulting mixture is cooled to room temperature and filtered through a pad of celite. The filtrate is diluted with ethyl acetate and washed with water. The organic layer is dried over magnesium sulfate, filtered and concentrated. The crude is purified via column chromatography to afford tert-butyl (6-(5-(azetidine-1-carbonyl)-6-chloro-4-isobutyl-1H-indol-1-yl)-5-chloropyrimidin-4-yl)carbamate (7).

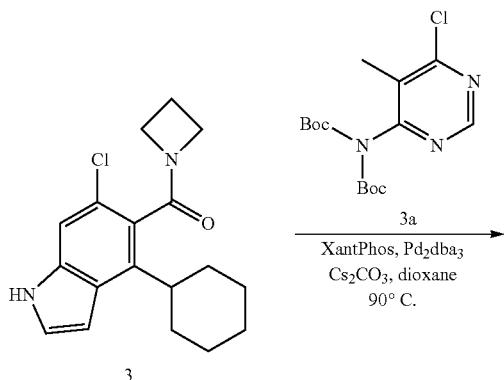
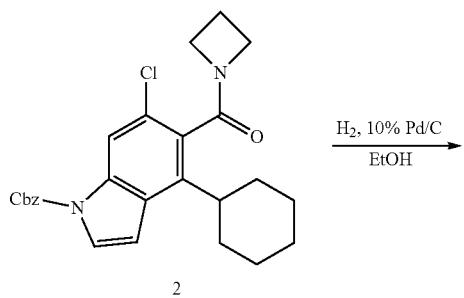
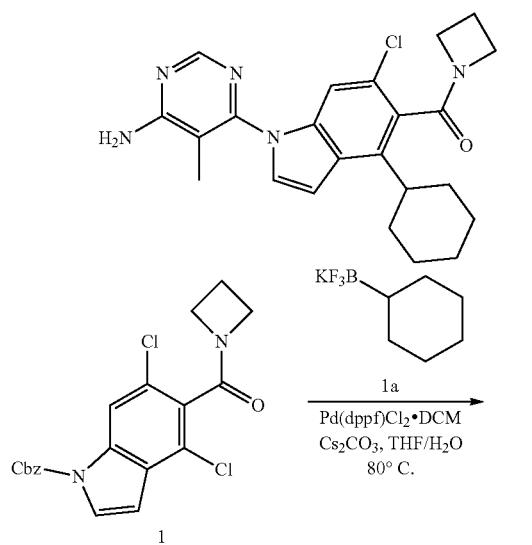
55 Synthesis of (1-(6-amino-5-chloropyrimidin-4-yl)-6-chloro-4-isobutyl-1H-indol-5-yl)(azetidin-1-yl)methanone (Cpd. No. 4F)

60 tert-Butyl (6-(5-(azetidine-1-carbonyl)-6-chloro-4-isobutyl-1H-indol-1-yl)-5-chloropyrimidin-4-yl)carbamate (7, 1

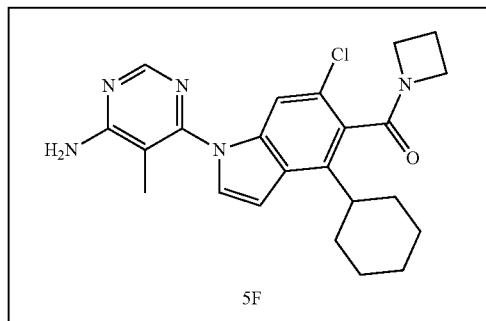
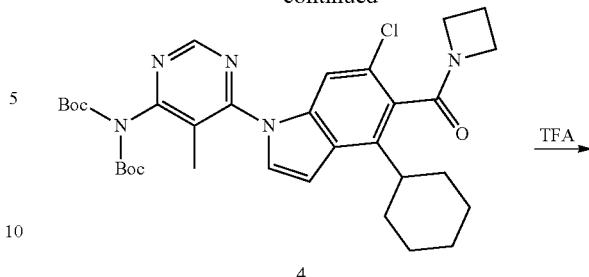
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g, 1.93 mmol) is dissolved in trifluoroacetic acid (10 mL). The reaction is stirred at room temperature overnight. The resulting mixture is concentrated and purified via reversed phase HPLC to afford (1-(6-amino-5-chloropyrimidin-4-yl)-6-chloro-4-isobutyl-1H-indol-5-yl)(azetidin-1-yl)methanone (Cpd. No. 4F) as a trifluoroacetic acid salt.

Example 5: (1-(6-amino-5-methylpyrimidin-4-yl)-6-chloro-4-cyclohexyl-1H-indol-5-yl)(azetidin-1-yl)methanone (Cpd. No. 5F)

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Synthesis of benzyl 5-(azetidine-1-carbonyl)-6-chloro-4-cyclohexyl-1H-indole-1-carboxylate (2)

A mixture of benzyl 5-(azetidine-1-carbonyl)-4,6-dichloro-1H-indole-1-carboxylate (1, 1.44 g, 3.56 mmol), cyclohexyltrifluoro- λ^4 -borane, potassium salt (1a, 1.35 g, 7.12 mmol) and cesium carbonate (3.48 g, 10.68 mmol) in tetrahydrofuran (20 mL) and water (5 mL) is purged with argon for 5 min. [1,1'-Bis(diphenylphosphino)ferrocene]dichloropalladium(II), complex with dichloromethane (0.29 g, 0.36 mmol) is added and the mixture is purged with argon for another 5 min. The reaction is sealed and stirred at 80° C. overnight. The resulting mixture is cooled to room temperature and filtered through a pad of celite. The filtrate is diluted with ethyl acetate and washed with water. The organic layer is dried over magnesium sulfate, filtered and concentrated. The crude is purified via column chromatography to afford benzyl 5-(azetidine-1-carbonyl)-6-chloro-4-cyclohexyl-1H-indole-1-carboxylate (2).

Synthesis of azetidin-1-yl(6-chloro-4-cyclohexyl-1H-indol-5-yl)methanone (3)

To a solution of benzyl 5-(azetidine-1-carbonyl)-6-chloro-4-cyclohexyl-1H-indole-1-carboxylate (2, 1 g, 2.22 mmol) in ethanol (20 mL) is added 10% palladium on carbon (100 mg). The mixture is purged with hydrogen and stirred under hydrogen atmosphere overnight. The resulting mixture is filtered through a pad of celite and concentrated. The crude is purified via column chromatography to afford azetidin-1-yl(6-chloro-4-cyclohexyl-1H-indol-5-yl)methanone (3).

Synthesis of tert-butyl N-tert-butoxycarbonyl-N-(6-(5-azetidine-1-carbonyl)-6-chloro-4-cyclohexyl-1H-indol-5-yl)-5-methylpyrimidin-4-yl)carbamate (4)

A mixture of azetidin-1-yl(6-chloro-4-cyclohexyl-1H-indol-5-yl)methanone (3, 1.13 g, 3.58 mmol), tert-butyl N-tert-butoxycarbonyl-N-(6-chloro-5-methyl-pyrimidin-4-

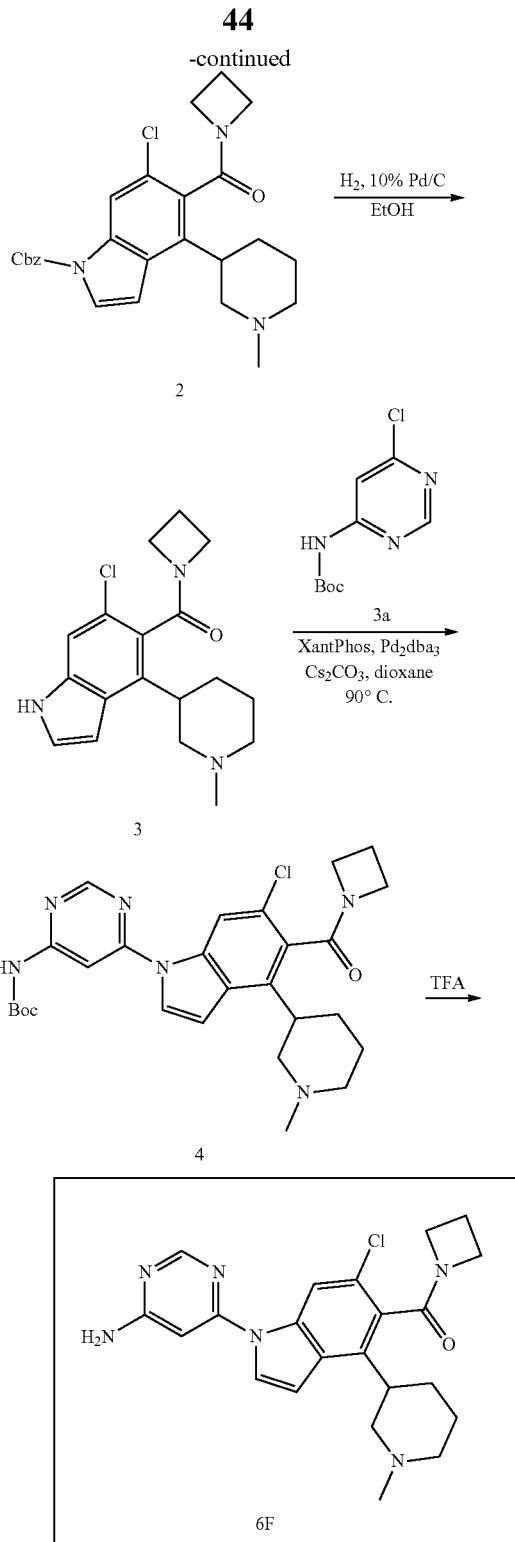
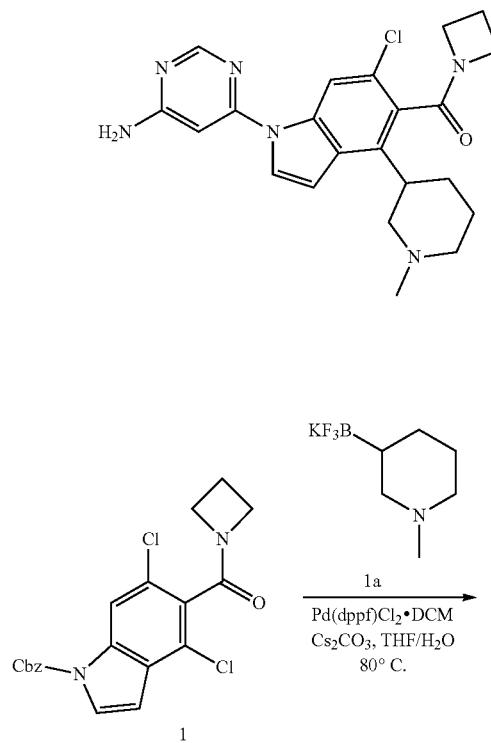
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yl)carbamate (3a, 1.23 g, 3.58 mmol) and cesium carbonate (3.50 g, 10.74 mmol) in dioxane (20 mL) is purged with argon for 5 min. XantPhos (0.42 g, 0.72 mmol) and tris (dibenzylideneacetone)dipalladium(0) (0.33 g, 0.36 mmol) are added and the mixture is purged with argon for another 5 min. The reaction is sealed and stirred at 90° C. overnight. The resulting mixture is cooled to room temperature and filtered through a pad of celite. The filtrate is diluted with ethyl acetate and washed with water. The organic layer is dried over magnesium sulfate, filtered and concentrated. The crude is purified via column chromatography to afford tert-butyl N-tert-butoxycarbonyl-N-(6-(5-(azetidine-1-carbonyl)-6-chloro-4-cyclohexyl-1H-indol-1-yl)-5-methylpyrimidin-4-yl)carbamate (4).

Synthesis of (1-(6-amino-5-methylpyrimidin-4-yl)-6-chloro-4-cyclohexyl-1H-indol-5-yl)(azetidin-1-yl) methanone (Cpd. No. 5F)

tert-Butyl N-tert-butoxycarbonyl-N-(6-(5-(azetidine-1-carbonyl)-6-chloro-4-cyclohexyl-1H-indol-1-yl)-5-methylpyrimidin-4-yl)carbamate (4, 1 g, 1.60 mmol) is dissolved in trifluoroacetic acid (10 mL). The reaction is stirred at room temperature overnight. The resulting mixture is concentrated and purified via reversed phase HPLC to afford (1-(6-amino-5-methylpyrimidin-4-yl)-6-chloro-4-cyclohexyl-1H-indol-5-yl)(azetidin-1-yl)methanone (Cpd. No. 5F) as a trifluoroacetic acid salt.

Example 6: (1-(6-aminopyrimidin-4-yl)-6-chloro-4-(1-methylpiperidin-3-yl)-1H-indol-5-yl)(azetidin-1-yl)methanone (Cpd. No. 6F)



Synthesis of benzyl 5-(azetidine-1-carbonyl)-6-chloro-4-(1-methylpiperidin-3-yl)-1H-indole-1-carboxylate (2)

A mixture of benzyl 5-(azetidine-1-carbonyl)-4,6-dichloro-1H-indole-1-carboxylate (1, 1.44 g, 3.56 mmol), 1-methyl-3-(trifluoro- λ^4 -boranyl)piperidine, potassium salt (1a, 1.46 g, 7.12 mmol) and cesium carbonate (3.48 g, 10.68

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mmol) in tetrahydrofuran (20 mL) and water (5 mL) is purged with argon for 5 min. [1,1'-Bis(diphenylphosphino)ferrocene]dichloropalladium(II), complex with dichloromethane (0.29 g, 0.36 mmol) is added and the mixture is purged with argon for another 5 min. The reaction is sealed and stirred at 80° C. overnight. The resulting mixture is cooled to room temperature and filtered through a pad of celite. The filtrate is diluted with ethyl acetate and washed with water. The organic layer is dried over magnesium sulfate, filtered and concentrated. The crude is purified via column chromatography to afford benzyl 5-(azetidine-1-carbonyl)-6-chloro-4-(1-methylpiperidin-3-yl)-1H-indole-1-carboxylate (2).

Synthesis of azetidin-1-yl(6-chloro-4-(1-methylpiperidin-3-yl)-1H-indol-5-yl)methanone (3)

To a solution of benzyl 5-(azetidine-1-carbonyl)-6-chloro-4-(1-methylpiperidin-3-yl)-1H-indole-1-carboxylate (2, 1 g, 3.01 mmol) in ethanol (20 mL) is added 10% palladium on carbon (100 mg). The mixture is purged with hydrogen and stirred under hydrogen atmosphere overnight. The resulting mixture is filtered through a pad of celite and concentrated. The crude is purified via column chromatography to afford azetidin-1-yl(6-chloro-4-(1-methylpiperidin-3-yl)-1H-indol-5-yl)methanone (3).

Synthesis of tert-butyl (6-(5-(azetidine-1-carbonyl)-6-chloro-4-(1-methylpiperidin-3-yl)-1H-indol-1-yl)pyrimidin-4-yl)carbamate (4)

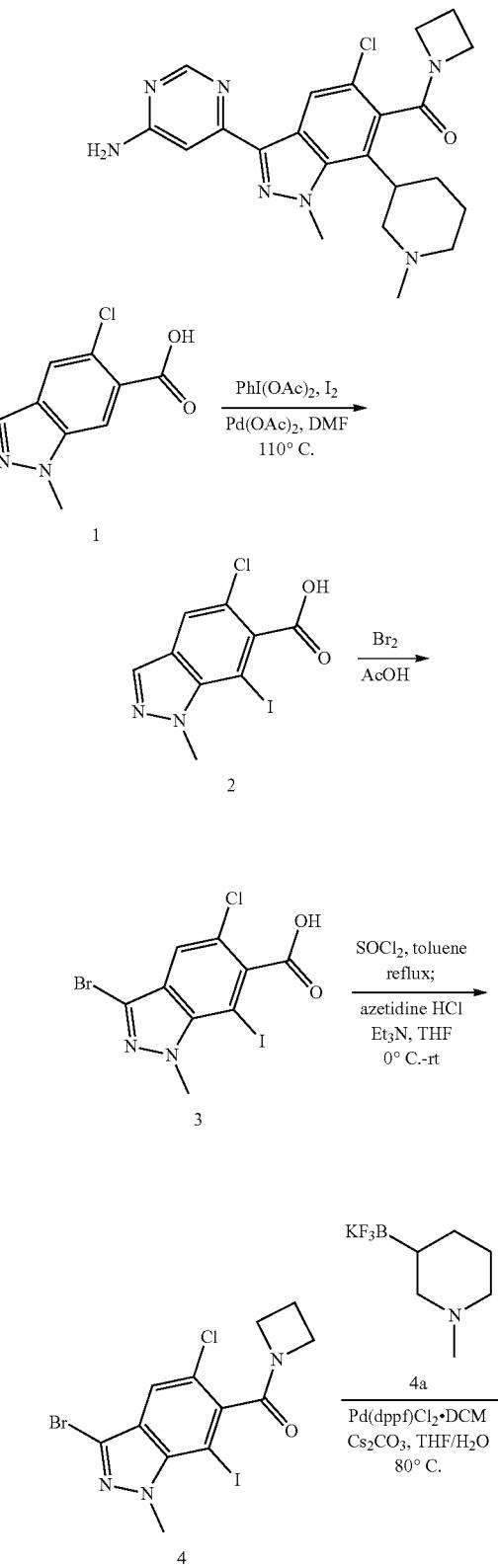
A mixture of azetidin-1-yl(6-chloro-4-(1-methylpiperidin-3-yl)-1H-indol-5-yl)methanone (3, 1.19 g, 3.58 mmol), tert-butyl (6-chloropyrimidin-4-yl)carbamate (3a, 0.82 g, 3.58 mmol) and cesium carbonate (3.50 g, 10.74 mmol) in dioxane (20 mL) is purged with argon for 5 min. XantPhos (0.42 g, 0.72 mmol) and tris(dibenzylideneacetone)dipalladium(0) (0.33 g, 0.36 mmol) are added and the mixture is purged with argon for another 5 min. The reaction is sealed and stirred at 90° C. overnight. The resulting mixture is cooled to room temperature and filtered through a pad of celite. The filtrate is diluted with ethyl acetate and washed with water. The organic layer is dried over magnesium sulfate, filtered and concentrated. The crude is purified via column chromatography to afford tert-butyl (6-(5-(azetidine-1-carbonyl)-6-chloro-4-(1-methylpiperidin-3-yl)-1H-indol-1-yl)pyrimidin-4-yl)carbamate (4).

Synthesis of (1-(6-aminopyrimidin-4-yl)-6-chloro-4-(1-methylpiperidin-3-yl)-1H-indol-5-yl)(azetidin-1-yl)methanone (Cpd. No. 6F)

tert-Butyl (6-(5-(azetidine-1-carbonyl)-6-chloro-4-(1-methylpiperidin-3-yl)-1H-indol-1-yl)pyrimidin-4-yl)carbamate (4, 1 g, 1.90 mmol) is dissolved in trifluoroacetic acid (10 mL). The reaction is stirred at room temperature overnight. The resulting mixture is concentrated and purified via reversed phase HPLC to afford (1-(6-aminopyrimidin-4-yl)-6-chloro-4-(1-methylpiperidin-3-yl)-1H-indol-5-yl)(azetidin-1-yl)methanone (Cpd. No. 6F) as a trifluoroacetic acid salt.

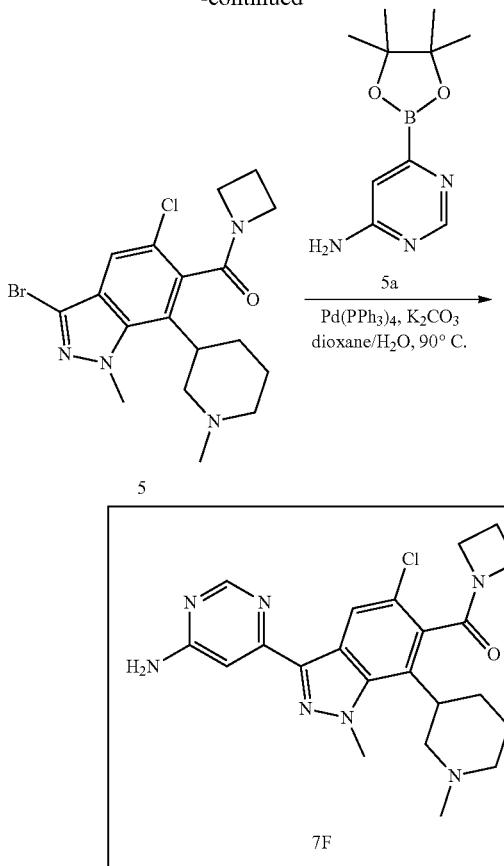
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Example 7: (3-(6-aminopyrimidin-4-yl)-5-chloro-1-methyl-7-(1-methylpiperidin-3-yl)-1H-indazol-6-yl)(azetidin-1-yl)methanone (Cpd. No. 7F)



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Synthesis of 5-chloro-7-iodo-1-methyl-1H-indazole-6-carboxylic acid (2)

A mixture of 5-chloro-1-methyl-1H-indazole-6-carboxylic acid (1, 1 g, 4.75 mmol), iodine (2.41 g, 9.50 mmol), (diacetoxymethoxy)benzene (3.06 g, 9.50 mmol) and palladium acetate (0.11 g, 0.48 mmol) in N,N-dimethylformamide (5 mL) is purged with argon for 5 min. The reaction is sealed and stirred at 110° C. overnight. The resulting mixture is cooled to room temperature, diluted with ethyl acetate and quenched with half saturated sodium disulfite solution. The organic layer is dried over magnesium sulfate, filtered and concentrated. The crude is purified via column chromatography to afford 5-chloro-7-iodo-1-methyl-1H-indazole-6-carboxylic acid (2).

Synthesis of 3-bromo-5-chloro-7-iodo-1-methyl-1H-indazole-6-carboxylic acid (3)

To a solution of 5-chloro-7-iodo-1-methyl-1H-indazole-6-carboxylic acid (2, 1 g, 2.97 mmol) in glacial acetic acid (10 mL) is added bromine (1.42 g, 8.91 mmol). The reaction is stirred at room temperature overnight. The resulting mixture is slowly added into a saturated sodium bicarbonate solution. The mixture is extracted with ethyl acetate. The combined organics are dried over magnesium sulfate, filtered and concentrated. The crude is purified via column chromatography to afford 3-bromo-5-chloro-7-iodo-1-methyl-1H-indazole-6-carboxylic acid (3).

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Synthesis of azetidin-1-yl(3-bromo-5-chloro-7-iodo-1-methyl-1H-indazol-6-yl)methanone (4)

To a stirred solution of 3-bromo-5-chloro-7-iodo-1-methyl-1H-indazole-6-carboxylic acid (3, 1 g, 2.41 mmol) in toluene (10 mL) is added thionyl chloride (10 mL) slowly. The reaction is stirred at reflux for 2 h. The resulting mixture is cooled to room temperature, concentrated and dried under vacuum.

To a solution of the above crude in tetrahydrofuran at 0° C. is added trimethylamine (3.36 mL, 24.1 mmol) and azetidine hydrochloride (0.90 g, 9.64 mmol). The reaction is stirred at room temperature for 1 h. The resulting mixture is diluted with ethyl acetate and washed with water. The organic layer is dried over magnesium sulfate, filtered and concentrated. The crude is purified via column chromatography to afford azetidin-1-yl(3-bromo-5-chloro-7-iodo-1-methyl-1H-indazol-6-yl)methanone (4).

Synthesis of azetidin-1-yl(3-bromo-5-chloro-1-methyl-7-(1-methylpiperidin-3-yl)-1H-indazol-6-yl)methanone (5)

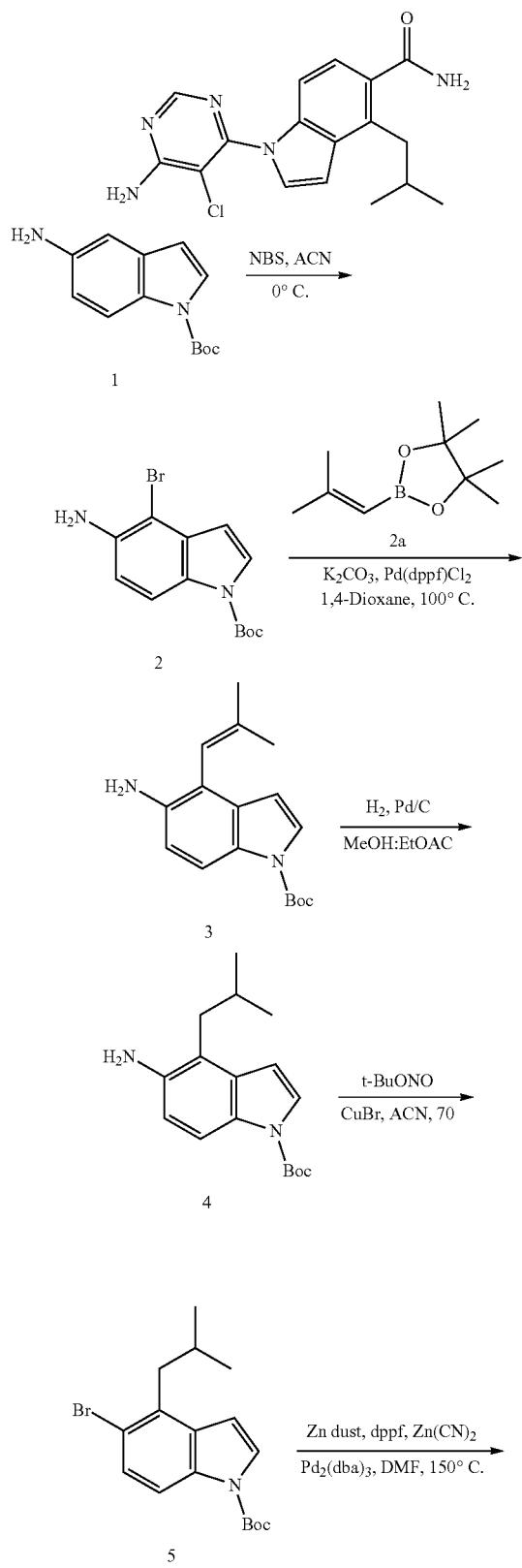
A mixture of azetidin-1-yl(3-bromo-5-chloro-7-iodo-1-methyl-1H-indazol-6-yl)methanone (4, 1.62 g, 3.56 mmol), 1-methyl-3-(trifluoro- λ^4 -boraneyl)piperidine, potassium salt (4a, 1.46 g, 7.12 mmol) and cesium carbonate (3.48 g, 10.68 mmol) in tetrahydrofuran (20 mL) and water (5 mL) is purged with argon for 5 min. [1,1'-Bis(diphenylphosphino)ferrocene]dichloropalladium(II), complex with dichloromethane (0.29 g, 0.36 mmol) is added and the mixture is purged with argon for another 5 min. The reaction is sealed and stirred at 80° C. overnight. The resulting mixture is cooled to room temperature and filtered through a pad of celite. The filtrate is diluted with ethyl acetate and washed with water. The organic layer is dried over magnesium sulfate, filtered and concentrated. The crude is purified via column chromatography to afford azetidin-1-yl(3-bromo-5-chloro-1-methyl-7-(1-methylpiperidin-3-yl)-1H-indazol-6-yl)methanone (5).

Synthesis of (3-(6-aminopyrimidin-4-yl)-5-chloro-1-methyl-7-(1-methylpiperidin-3-yl)-1H-indazol-6-yl)(azetidin-1-yl)methanone (Cpd. No. 7F)

A mixture of azetidin-1-yl(3-bromo-5-chloro-1-methyl-7-(1-methylpiperidin-3-yl)-1H-indazol-6-yl)methanone (5, 1.52 g, 3.58 mmol), 6-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)pyrimidin-4-amine (5a, 0.79 g, 3.58 mmol) and potassium carbonate (1.48 g, 10.74 mmol) in dioxane (20 mL) and water (4 mL) is purged with argon for 5 min. Tetrakis(triphenylphosphine)palladium(0) (0.42 g, 0.36 mmol) is added and the mixture is purged with argon for another 5 min. The reaction is sealed and stirred at 90° C. overnight. The resulting mixture is cooled to room temperature and filtered through a pad of celite. The filtrate is diluted with ethyl acetate and washed with water. The organic layer is dried over magnesium sulfate, filtered and concentrated. The crude is purified via column chromatography to afford (3-(6-aminopyrimidin-4-yl)-5-chloro-1-methyl-7-(1-methylpiperidin-3-yl)-1H-indazol-6-yl)(azetidin-1-yl)methanone (Cpd. No. 7F).

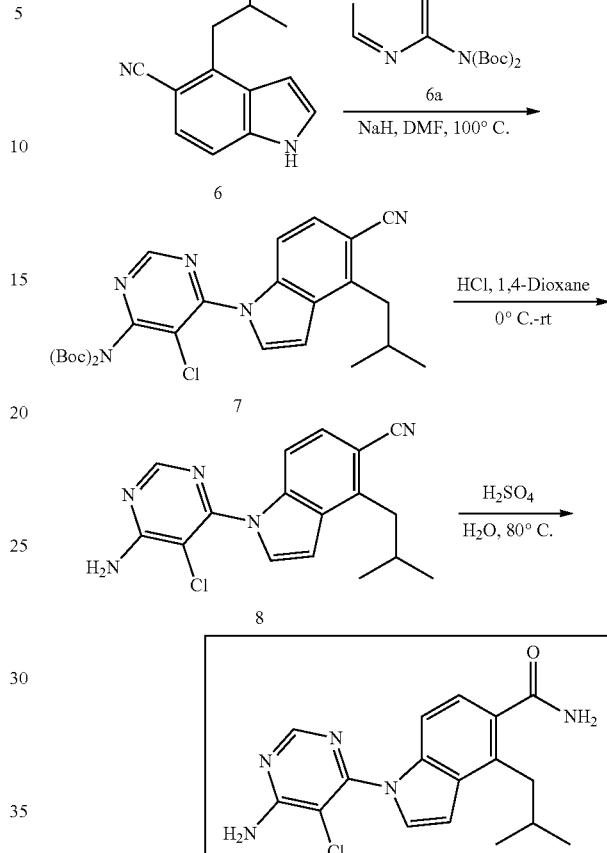
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Example 8: 1-(6-amino-5-chloropyrimidin-4-yl)-4-isobutyl-1H-indole-5-carboxamide (Cpd. No. 8F)



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-continued



Synthesis of tert-butyl 5-amino-4-bromo-1H-indole-1-carboxylate (2)

45 To a stirred solution of tert-butyl 5-amino-1H-indole-1-carboxylate (1, 5.0 g, 21.55 mmol) in acetonitrile (50 mL) at 0°C., N-bromosuccinimide (4.23 g, 23.70 mmol) was added portion-wise. The mixture was stirred at same temperature for 3 h. Next, the reaction was poured into ice-cold water and extracted with ethyl acetate. The organic layer was washed with brine solution, dried over anhydrous sodium sulfate, filtered, and concentrated to dryness under reduced pressure. The crude product was purified by CombiFlash (40 g, RediSep column) using 0-30% ethyl acetate in hexanes as eluent. The desired fractions were concentrated under reduced pressure to afford tert-butyl 5-amino-4-bromo-1H-indole-1-carboxylate (2) as a brown liquid. Yield: 5.8 g, 86%; MS (ESI) m/z 311.08 [M+1]⁺.

60 **Synthesis of tert-butyl 5-amino-4-(2-methylprop-1-en-1-yl)-1H-indole-1-carboxylate (3)**

65 To a solution of tert-butyl 5-amino-4-bromo-1H-indole-1-carboxylate (2, 5.8 g, 18.64 mmol) and 4,4,5,5-tetramethyl-2-(2-methylprop-1-en-1-yl)-1,3,2-dioxaborolane (2a, 4.41 g, 24.24 mmol) in 1,4-dioxane (60 mL) at room temperature, potassium carbonate (2 M in water, 18.6 mL,

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37.29 mmol) was added. The mixture was degassed with argon gas for 10 minutes. Then, [1,1'-Bis(diphenylphosphino)ferrocene]palladium(II) dichloride (1.36 g, 1.86 mmol) was added and the reaction mixture was heated at 100° C. for 8 h. After completion, the reaction mixture was filtered with celite and washed with ethyl acetate. The filtrate was washed with brine solution, dried over anhydrous sodium sulfate, filtered, and concentrated to dryness under reduced pressure. The crude product was purified by CombiFlash (40 g, RediSep column) using 0-20% ethyl acetate in hexanes as eluent. The desired fractions were concentrated under reduced pressure to afford tert-butyl 5-amino-4-(2-methylprop-1-en-1-yl)-1H-indole-1-carboxylate (3) as a thick brown syrup. Yield: 4.2 g, 78%; MS (ESI) m/z 387.22 [M+1]⁺.

Synthesis of tert-butyl
5-amino-4-isobutyl-1H-indole-1-carboxylate (4)

To a solution of tert-butyl 5-amino-4-(2-methylprop-1-en-1-yl)-1H-indole-1-carboxylate (3, 4.2 g, 14.68 mmol) in methanol (40 mL) and ethyl acetate (40 mL) at room temperature, palladium on carbon (50%, 1.55 g, 7.34 mmol) was added. The reaction mixture was stirred under hydrogen atmosphere (balloon) for 2 h. Next, the reaction mixture was filtered with celite and washed with methanol. The filtrate was concentrated to dryness under reduced pressure. The crude product was purified by CombiFlash (40 g, RediSep column) using 0-10% ethyl acetate in hexanes as eluent. The desired fractions were concentrated under reduced pressure to afford tert-butyl 5-amino-4-isobutyl-1H-indole-1-carboxylate (4) as a brown liquid. Yield: 3.7 g, 87%; MS (ESI) m/z 289.18 [M+1]⁺.

Synthesis of tert-butyl
5-bromo-4-isobutyl-1H-indole-1-carboxylate (5)

To a solution of tert-butyl 5-amino-4-isobutyl-1H-indole-1-carboxylate (4, 3.6 g, 12.5 mmol) in acetonitrile (40 mL) at room temperature, t-butyl nitrite (3.21 mL, 25.00 mmol) was added followed by copper (I) bromide (2.68 g, 18.75 mmol). The mixture was heated at 70° C. for 3 h. Then, the reaction mixture was diluted with water and extracted with ethyl acetate. The organic layer was washed with brine solution, dried over anhydrous sodium sulfate, filtered, and concentrated to dryness under reduced pressure. The crude product was purified by CombiFlash (40 g, RediSep column) using 0-10% ethyl acetate in hexanes as eluent. The desired fractions were concentrated under reduced pressure to afford tert-butyl 5-bromo-4-isobutyl-1H-indole-1-carboxylate (5) as an off-white solid. Yield: 1.2 g, 27%; MS (ESI) m/z 352.19 [M+1]⁺.

Synthesis of 4-isobutyl-1H-indole-5-carbonitrile (6)

To a solution of tert-butyl 5-bromo-4-isobutyl-1H-indole-1-carboxylate (5, 0.5 g, 1.42 mmol) in N,N-dimethylformamide (10 mL), zinc cyanide (0.99 g, 8.54 mmol) and zinc dust (0.27 g, 4.27 mmol) were added. This reaction mixture was degassed with argon gas for 10 minutes. Then, 1,1'-bis(diphenylphosphanyl) ferrocene (0.087 g, 0.15 mmol) and tris(dibenzylideneacetone)dipalladium (0.065 g, 0.071 mmol) were added to the reaction mixture which was heated at 150° C. for 5 h. After this time, the mixture was poured into ice-cold water and extracted with ethyl acetate. The organic layer was washed with brine solution, dried over anhydrous sodium sulfate, filtered, and concentrated to

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dryness under reduced pressure. The crude product was purified by CombiFlash (12 g, RediSep column) using 0-30% ethyl acetate in hexane as eluent. The desired fractions were concentrated under reduced pressure to afford 4-isobutyl-1H-indole-5-carbonitrile (6) as a brown solid. Yield: 0.24 g, (crude); MS (ESI) m/z 197.24 [M-1]⁻.

Synthesis of ditert-butylcarbamate 1-(6-amino-5-chloropyrimidin-4-yl)-4-isobutyl-1H-indole-5-carbonitrile (7)

To a solution of 4-isobutyl-1H-indole-5-carbonitrile (6, 0.3 g, 1.51 mmol) in N,N-dimethylformamide (5 mL) at room temperature, sodium hydride (60% in mineral oil) (0.083 g, 2.27 mmol) was added portion-wise. This reaction mixture was stirred for 20 minutes. Ditert-butyl (5,6-dichloropyrimidin-4-yl)dicarbamate (6a, 0.61 g, 1.66 mmol) was added and the reaction mixture was heated at 100° C. for 12 h. After this time, the mixture was poured into ice-cold water and extracted with ethyl acetate. The organic layer was washed with brine solution, dried over anhydrous sodium sulfate, filtered, and concentrated to dryness under reduced pressure to afford ditert-butylcarbamate 1-(6-amino-5-chloropyrimidin-4-yl)-4-isobutyl-1H-indole-5-carbonitrile (7) as a brown liquid. Yield: 0.55 g, (crude); MS (ESI) m/z 424.24 [M-1]⁻.

Synthesis of 1-(6-amino-5-chloropyrimidin-4-yl)-4-isobutyl-1H-indole-5-carbonitrile (8)

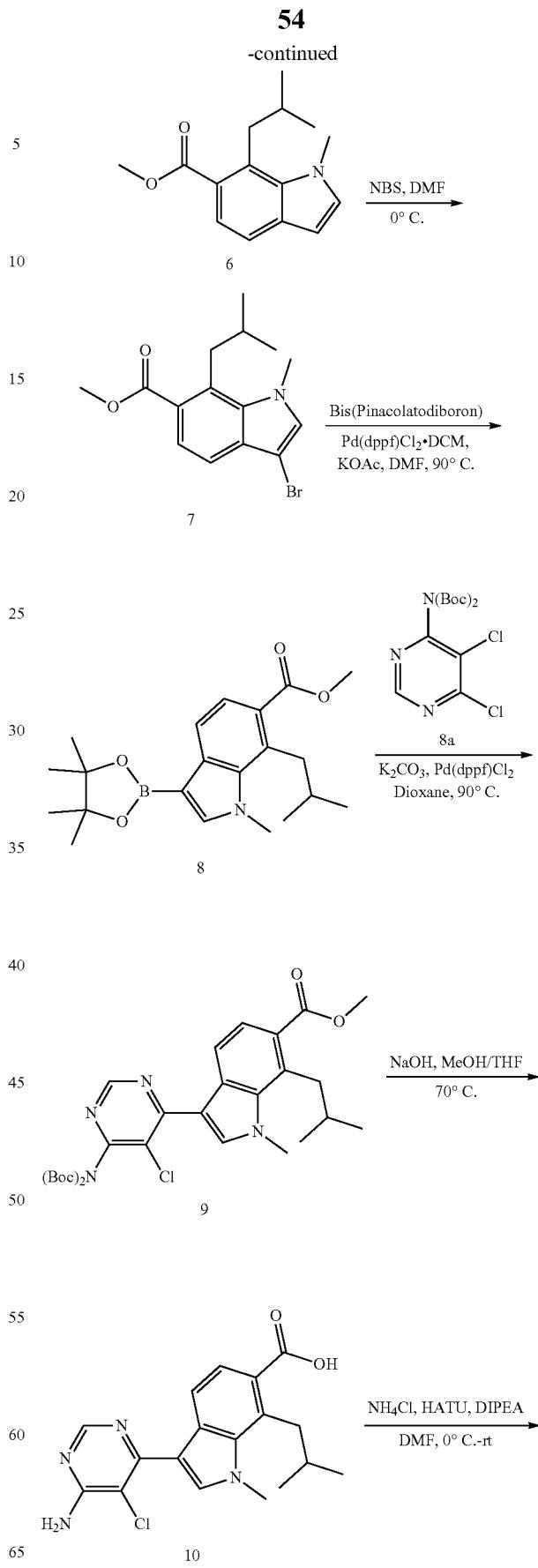
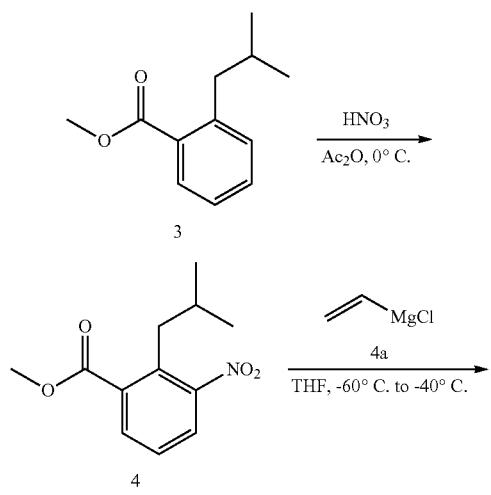
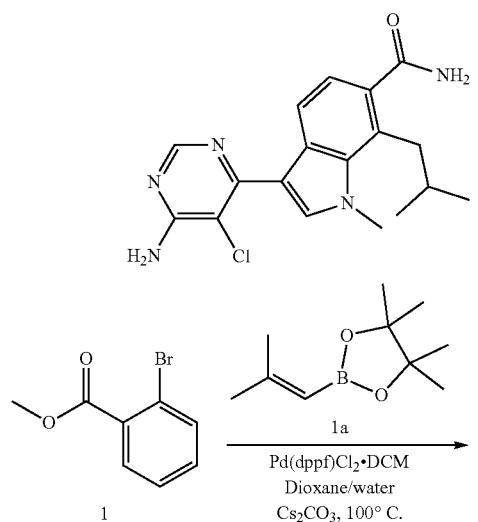
To a solution of ditert-butylcarbamate 1-(6-amino-5-chloropyrimidin-4-yl)-4-isobutyl-1H-indole-5-carbonitrile (7, 0.55 g, 1.29 mmol) in 1,4-dioxane (5 mL) at 0° C., hydrochloric acid (4 M in 1,4-dioxane, 5 mL) was added. This reaction mixture was stirred for 6 h at room temperature. After this time, the reaction mixture was concentrated under reduced pressure to obtain a residue. This residue was diluted with ethyl acetate and washed with saturated sodium bicarbonate solution. The organic layer was separated, washed with brine solution, dried over anhydrous sodium sulfate, filtered, and concentrated to dryness under reduced pressure to afford 1-(6-amino-5-chloropyrimidin-4-yl)-4-isobutyl-1H-indole-5-carbonitrile (8) as an off-white solid. Yield: 0.17 g, 40.4%; MS (ESI) m/z 326.28 [M+1]⁺.

Synthesis of 1-(6-amino-5-chloropyrimidin-4-yl)-4-isobutyl-1H-indole-5-carboxamide (Cpd. No. 8F)

To a solution of 1-(6-amino-5-chloropyrimidin-4-yl)-4-isobutyl-1H-indole-5-carbonitrile (8, 0.15 g, 0.46 mmol) in sulfuric acid (7.5 mL) at 0° C. was added water (catalytic). This reaction mixture was heated at 80° C. for 16 h. After this time, the reaction was poured into ice-cold water, basified to pH 8-9 with potassium carbonate, and extracted with ethyl acetate. The organic layer was washed with brine solution, dried over anhydrous sodium sulfate, filtered, and concentrated to dryness under reduced pressure. The crude product was purified by prep-HPLC to afford 1-(6-amino-5-chloropyrimidin-4-yl)-4-isobutyl-1H-indole-5-carboxamide (Cpd. No. 8F) as an off-white solid. Yield: 0.011 g, 7%; MS (ESI) m/z 344.15 [M+1]⁺; ¹H NMR (400 MHz, DMSO-d₆) δ 8.36 (s, 1H), 8.04 (bs, 1H), 7.71 (d, J=3.28 Hz, 1H), 7.62 (s, 1H), 7.51 (bs, 1H), 7.34 (d, J=8.48 Hz, 1H), 7.22 (t, J=4.52 Hz, 2H), 6.82 (d, J=3.24 Hz, 1H), 3.00 (d, J=7.04 Hz, 2H), 2.01-1.94 (m, 1H), 0.85 (d, J=6.52, 6H).

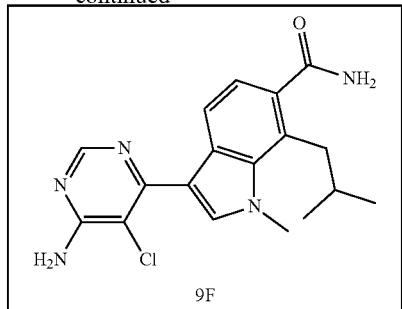
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Example 9: 3-(6-amino-5-chloropyrimidin-4-yl)-7-isobutyl-1-methyl-1H-indole-6-carboxamide (Cpd. No. 9F)



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-continued



Synthesis of methyl
2-(2-methylprop-1-en-1-yl)benzoate (2)

To a solution of methyl 2-bromobenzoate (1, 9.5 g, 44.18 mmol) and 4,4,5,5-tetramethyl-2-(2-methylprop-1-en-1-yl)-1,3,2-dioxaborolane (1a, 12.06 g, 66.27 mmol) in 1,4-dioxane (80 mL) and water (20 mL), cesium carbonate (28.7 g, 88.37 mmol) was added at room temperature. This reaction mixture was degassed with argon gas for 10 minutes. Then, [1,1'-Bis(diphenylphosphino)ferrocene]palladium(II) dichloride.dichloromethane (3.6 g, 4.41 mmol) was added and the mixture was heated at 100° C. for 2 h. Next, the reaction mixture was filtered with celite and washed with ethyl acetate. The filtrate was washed with brine solution, dried over anhydrous sodium sulfate, filtered, and concentrated to dryness under reduced pressure. The crude product was purified by CombiFlash (80 g, RediSep column) using 0-10% ethyl acetate in hexanes as eluent. The desired fractions were concentrated under reduced pressure to afford methyl 2-(2-methylprop-1-en-1-yl)benzoate (2) as a brown syrup. Yield: 8.1 g, 96%; MS (ESI) m/z 191.16 [M+1]⁺.

Synthesis of methyl 2-isobutylbenzoate (3)

To a solution methyl 2-(2-methylprop-1-en-1-yl)benzoate (2, 8.1 g, 42.63 mmol) in methanol (80 mL), palladium on carbon (50%, 2.25 g, 21.31 mmol) was added at room temperature. This reaction mixture was stirred under hydrogen atmosphere (balloon) for 2 h. Next, the reaction mixture was filtered with celite and washed with methanol. The filtrate was concentrated to dryness under reduced pressure. The crude product was purified by CombiFlash (80 g, RediSep column) using 0-10% ethyl acetate in hexanes as eluent. The desired fractions were concentrated under reduced pressure to afford methyl 2-isobutylbenzoate (3) as a brown liquid. Yield: 7.8 g, 88%; LCMS: No ionization. ¹H NMR (400 MHz, DMSO-d₆) δ 7.75 (d, J=7.68 Hz, 1H), 7.48 (dd, J=7.44 Hz, 1H), 7.32-7.26 (m, 2H), 3.85 (s, 3H), 2.78 (d, J=7 Hz, 2H), 1.82-1.71 (m, 1H), 0.84 (d, J=6.56, 6H).

Synthesis of methyl 2-isobutyl-3-nitrobenzoate (4)

To a solution of methyl 2-isobutylbenzoate (3, 7.7 g, 40.10 mmol) in acetic anhydride (56.86 mL, 601.56 mmol) at 0° C., fuming nitric acid (16.7 mL, 401.04 mmol) was added dropwise. The reaction mixture was stirred at room temperature for 16 h. After this time, the reaction mixture was poured into crushed ice and extracted with ethyl acetate. The organic layer was washed with saturated sodium bicarbonate solution. The organic layer was dried over anhydrous sodium sulfate, filtered, and concentrated to dryness under

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reduced pressure. The crude product was purified by silica gel (100-200 mesh) column chromatography using 0-3% ethyl acetate in hexanes as eluent. The desired fractions were concentrated under reduced pressure to afford methyl 2-isobutyl-3-nitrobenzoate (4) as a brown liquid. Yield: 2.8 g, 29%; LCMS: No ionization. ¹H NMR (400 MHz, DMSO-d₆) δ 8.01-7.95 (m, 2H), 7.58 (t, J=7.96 Hz, 1H), 3.87 (s, 3H), 2.91 (d, J=7.24 Hz, 2H), 1.71-1.11 (m, 1H), 0.78 (d, J=6.64, 6H).

Synthesis of methyl
7-isobutyl-1H-indole-6-carboxylate (5)

To a stirred solution of methyl 2-isobutyl-3-nitrobenzoate (4, 2.8 g, 11.81 mmol) in dry tetrahydrofuran (50 mL) at -60° C., vinylmagnesium chloride (4a, 1.0 M in tetrahydrofuran, 53.16 mL, 53.16 mmol) was added dropwise. This mixture was stirred for 1 h at -40° C. Then, the reaction mixture was allowed to warm up to 0° C. The reaction was quenched with saturated ammonium chloride solution and extracted with ethyl acetate. The organic layer was washed with brine solution, dried over anhydrous sodium sulfate, filtered, and concentrated. The crude product was purified by CombiFlash (40 g, RediSep column) using 0-10% ethyl acetate in hexanes as eluent. The desired fractions were concentrated under reduced pressure to afford methyl 7-isobutyl-1H-indole-6-carboxylate (5) as a brown solid. Yield: 1.4 g, 50%; MS (ESI) m/z 231.11 [M-1]⁻.

Synthesis of methyl
7-isobutyl-1-methyl-1H-indole-6-carboxylate (6)

To a solution of methyl 7-isobutyl-1H-indole-6-carboxylate (5, 1.4 g, 6.06 mmol) in tetrahydrofuran (15 mL) at 0° C., sodium hydride (60%, 0.44 g, 12.12 mmol) was added portion-wise. This mixture was stirred for 20 minutes. Methyl iodide (0.56 mL, 9.09 mmol) was added and the reaction mixture was stirred at room temperature for 2 h. Then, the reaction was poured into ice-cold water and extracted with ethyl acetate. The organic layer was washed with brine solution, dried over anhydrous sodium sulfate, filtered, and concentrated to dryness under reduced pressure to afford methyl 7-isobutyl-1-methyl-1H-indole-6-carboxylate (6) as a brown solid. Yield: 1.4 g, 94%; MS (ESI) m/z 246.30 [M+1]⁺.

Synthesis of methyl 3-bromo-7-isobutyl-1-methyl-1H-indole-6-carboxylate (7)

To a solution of methyl 7-isobutyl-1-methyl-1H-indole-6-carboxylate (6, 1.4 g, 5.71 mmol) in N,N-dimethylformamide (10 mL) at 0° C., N-bromosuccinimide (1.07 g, 5.71 mmol) was added. This mixture was stirred at same temperature 10 minutes. Then, the reaction was poured into ice cold water and extracted with ethyl acetate. The organic layer was washed with brine solution, dried over anhydrous sodium sulfate, filtered, and concentrated to dryness under reduced pressure. The crude product was purified by CombiFlash (12 g, RediSep column) using 0-10% ethyl acetate in hexanes as eluent. The desired fractions were concentrated under reduced pressure to afford methyl 3-bromo-7-isobutyl-1-methyl-1H-indole-6-carboxylate (7) as a brown solid. Yield: 1.49 g, 81%; MS (ESI) m/z 324.15 [M+1]⁺.

Synthesis of methyl 7-isobutyl-1-methyl-3-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-1H-indole-6-carboxylate (8)

To a solution methyl 3-bromo-7-isobutyl-1-methyl-1H-indole-6-carboxylate (7, 1.49 g, 4.59 mmol) and bis(pina-

colatodiboron) (3.59 g, 13.79 mmol) in N,N-dimethylformamide (15 mL), potassium acetate (2.25 g, 22.99 mmol) was added at room temperature. This reaction mixture was degassed with argon gas for 10 minutes. After completion of the reaction, [1,1'-bis(diphenylphosphino)ferrocene]palladium(II) dichloride.dichloromethane (0.56 g, 0.68 mmol) was added to the reaction mixture which was then heated at 90° C. for 3 h. Next, the reaction mixture was filtered through celite pad and washed with ethyl acetate. The filtrate was washed with brine solution, dried over anhydrous sodium sulfate, filtered, and concentrated to dryness under reduced pressure. The crude product was purified by CombiFlash (12 g, RediSep column) using 0-10% ethyl acetate in hexanes as eluent. The desired fractions were concentrated under reduced pressure to afford methyl 7-isobutyl-1-methyl-3-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-1H-indole-6-carboxylate (8) as an off-white solid. Yield: 0.72 g, 42%; MS (ESI) m/z 372.39 [M+1]⁺.

Synthesis of ditert-butylcarbamate methyl 3-(6-amino-5-chloropyrimidin-4-yl)-7-isobutyl-1-methyl-1H-indole-6-carboxylate (9)

To a solution of ditert-butyl (5,6-dichloropyrimidin-4-yl) di carbamate (8a, 0.35 g, 0.96 mmol) and methyl 7-isobutyl-1-methyl-3-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-1H-indole-6-carboxylate (8, 0.71 g, 1.92 mmol) in 1,4-dioxane (80 mL), a solution of potassium carbonate (2 M in water) (1.44 mL, 2.88 mmol) was added at room temperature. This reaction mixture was degassed with argon gas for 10 minutes. Then, [1,1'-bis(diphenylphosphino)ferrocene] palladium(II) dichloride (0.07 g, 0.09 mmol) was added to the reaction mixture which was heated at 90°C for 16 h. Next, the reaction mixture was filtered with celite and washed with ethyl acetate. The filtrate was washed with brine solution, dried over anhydrous sodium sulfate, filtered, and concentrated to dryness under reduced pressure. The crude product was purified by CombiFlash (12 g, RediSep column) using 0-20% ethyl acetate in hexanes as eluent. The desired fractions were concentrated under reduced pressure to afford ditert-butylcarbamate methyl 3-(6-amino-5-chloropyrimidin-4-yl)-7-isobutyl-1-methyl-1H-indole-6-carboxylate (9) as an off-white solid. Yield: 0.14 g, 26%; MS (ESI) m/z 573.38 [M+1]⁺.

Synthesis of 3-(6-amino-5-chloropyrimidin-4-yl)-7-isobutyl-1-methyl-1H-indole-6-carboxylic acid (10)

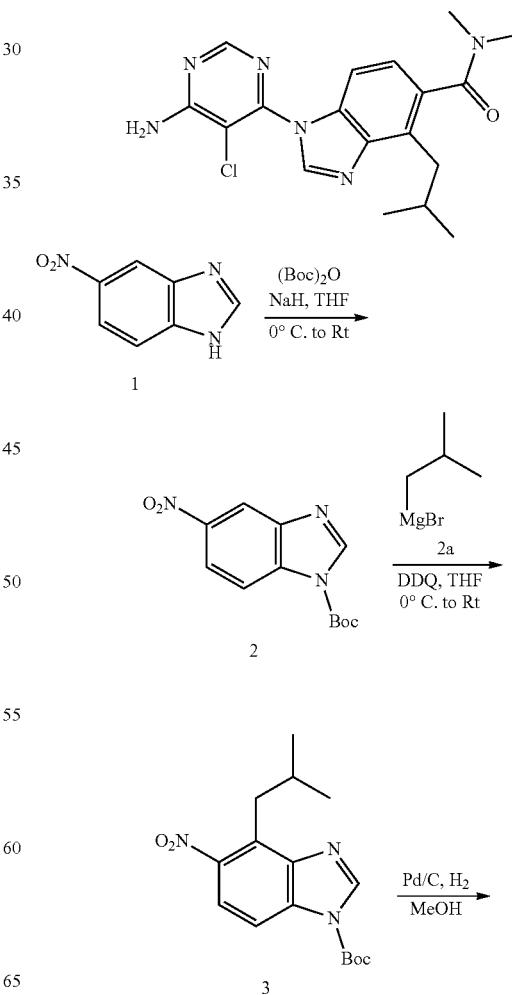
To a solution of tert-butylcarbamate methyl 3-(6-amino-5-chloropyrimidin-4-yl)-7-isobutyl-1-methyl-1H-indole-6-carboxylate (9, 0.14 g, 0.24 mmol) in tetrahydrofuran and methanol (5 mL), sodium hydroxide (2 M in water, 2.5 mL, 4.89 mmol) was added at room temperature. This reaction mixture was then heated to 70° C. for 16 h. After completion of the reaction, the reaction was concentrated to dryness under reduced pressure. The residue was dissolved in water, acidified with 1N hydrochloric acid solution, and extracted with ethyl acetate. The organic layer was washed with brine solution, dried over anhydrous sodium sulfate, filtered, and concentrated to dryness under reduced pressure to afford 3-(6-amino-5-chloropyrimidin-4-yl)-7-isobutyl-1-methyl-1H-indole-6-carboxylic acid (10) as an off-white solid. Yield: 0.06 g, 69%; MS (ESI) m/z 359.17 [M+1]⁺.

Synthesis of 3-(6-amino-5-chloropyrimidin-4-yl)-7-isobutyl-1-methyl-1H-indole-6-carboxamide (Cpd. No. 9F)

To a solution of 3-(6-amino-5-chloropyrimidin-4-yl)-7-isobutyl-1-methyl-1H-indole-6-carboxylic acid (10, 0.08 g,

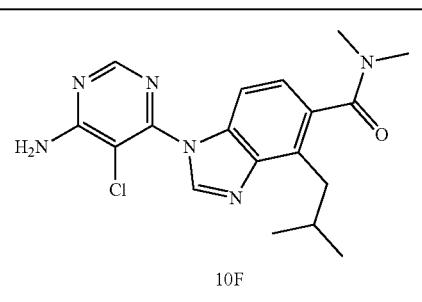
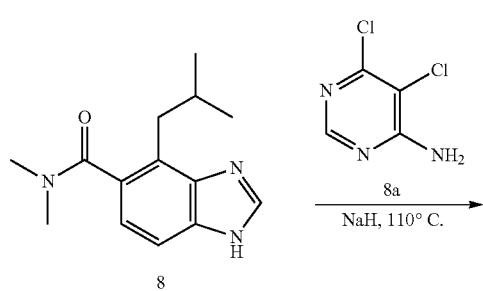
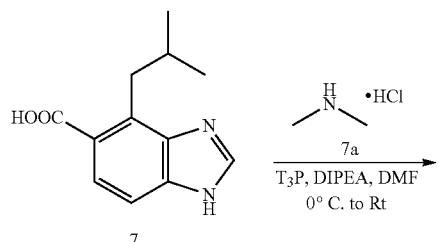
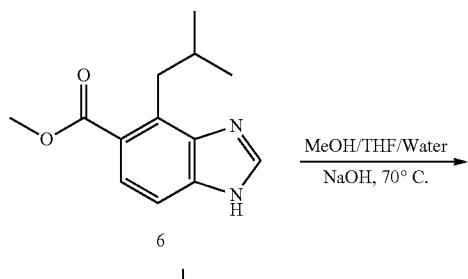
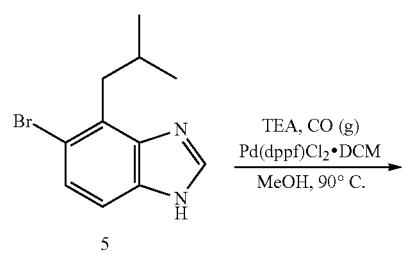
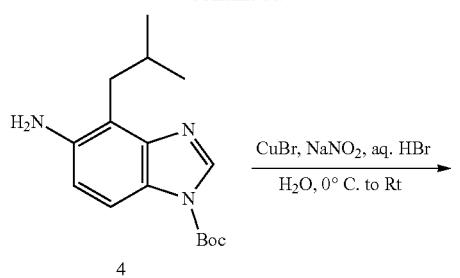
0.22 mmol) and ammonium chloride (0.06 g, 1.11 mmol) in N,N-dimethylformamide (3 mL) at 0° C., 1-[Bis(dimethylamino)methylene]-1H-1,2,3-triazolo[4,5-b]pyridinium 3-oxide hexafluorophosphate (0.13 g, 0.33 mmol) was added. After 15 min, N,N-diisopropylethyl amine (14.30 mL, 81.89 mmol) was added. This reaction mixture was stirred at room temperature for 16 h. After completion of the reaction, the reaction mixture was poured in to ice-cold water and extracted with ethyl acetate. The organic layer was washed with brine solution, dried over anhydrous sodium sulfate, filtered, and concentrated to dryness under reduced pressure. The crude product was triturated with methanol and diethyl ether, decanted, and dried to afford 3-(6-amino-5-chloropyrimidin-4-yl)-7-isobutyl-1-methyl-1H-indole-6-carboxamide (Cpd. No. 9F) as an off-white solid. Yield: 0.021 g, 26%; MS (ESI) m/z 358.15 [M+1]⁺; ¹H NMR (400 MHz, DMSO-d₆) δ 8.35 (s, 1H), 8.24-8.21 (m, 2H), 7.66 (s, 1H), 7.26 (s, 1H), 7.12 (d, J=8.4 Hz, 3H), 4.10 (s, 3H), 3.22 (d, J=7.2 Hz, 2H), 1.81 (m, 1H), 0.87 (d, J=6.4, 6H).

Example 10: 1-(6-amino-5-chloropyrimidin-4-yl)-4-isobutyl-N,N-dimethyl-1H-benzo[d]imidazole-5-carboxamide (Cpd. No. 10F)



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-continued



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Synthesis of tert-butyl 5-nitro-1H-benzo[d]imidazole-1-carboxylate (2)

To a solution of 5-nitro-1H-benzo[d]imidazole (1, 25.0 g, 153.37 mmol) in tetrahydrofuran (250 mL) at 0°C, sodium hydride (60%, 6.72 g, 168.71 mmol) was added portion-wise. This reaction mixture was stirred for 30 minutes. Then, di-tert-butyl dicarbonate (45.7 mL, 199.38 mmol) was added and the reaction mixture was stirred at room temperature for 16 h. After completion of the reaction, the reaction mixture was poured in to ice water and extracted with ethyl acetate. The organic layer was washed with brine solution, dried over anhydrous sodium sulfate, filtered, and concentrated to dryness under reduced pressure. The crude product was triturated with pentane, decanted, and dried to afford tert-butyl 5-nitro-1H-benzo[d]imidazole-1-carboxylate (2) as a yellow solid. Yield: 22.0 g, 54%; MS (ESI) m/z 264.09 [M+1]⁺.

20 Synthesis of tert-butyl 4-isobutyl-5-nitro-1H-benzo[d]imidazole-1-carboxylate (3)

To a solution of tert-butyl 5-nitro-1H-benzo[d]imidazole-1-carboxylate (2, 21.00 g, 79.84 mmol) in dry tetrahydrofuran (210 mL) at 0°C, isobutylmagnesium bromide (3.0 M in tetrahydrofuran, 80 mL, 239.52 mmol) was added dropwise. This reaction mixture was stirred at room temperature for 2 h. Then, 2,3-dichloro-5,6-dicyano-1,4-benzoquinone (18.12 g, 79.84 mmol) was added and stirring was continued at room temperature for 2 h. Next, the reaction mixture was poured in to ice water and extracted with ethyl acetate. The organic layer was washed with brine solution, dried over anhydrous sodium sulfate, filtered, and concentrated to dryness under reduced pressure. The crude product was purified by column silica gel (100-200 mesh) chromatography using 0-30% ethyl acetate in hexanes as eluent. The desired fractions were concentrated under reduced pressure to afford tert-butyl 4-isobutyl-5-nitro-1H-benzo[d]imidazole-1-carboxylate (3) as a brown liquid. Yield: 5.4 g, 21%; MS (ESI) m/z 320.09 [M+1]⁺.

Synthesis of tert-butyl 5-amino-4-isobutyl-1H-benzo[d]imidazole-1-carboxylate (4)

45 To a solution of tert-butyl 4-isobutyl-5-nitro-1H-benzo[d]imidazole-1-carboxylate (3, 5.35 g, 16.77 mmol) in methanol (50 mL), palladium on carbon (50%, 1.77 g, 8.38 mmol) was added under nitrogen atmosphere at room temperature. The reaction mixture was stirred under hydrogen atmosphere (balloon) at room temperature for 16 h. After completion of the reaction, the reaction mixture was filtered with celite and washed with methanol. The filtrate was concentrated to dryness under reduced pressure to afford tert-butyl 5-amino-4-isobutyl-1H-benzo[d]imidazole-1-carboxylate (4) as a brown solid. Yield: 4.0 g, 82%; MS (ESI) m/z 290.27 [M+1]⁺.

Synthesis of 5-bromo-4-isobutyl-1H-benzo[d]imidazole (5)

60 To a stirred solution of tert-butyl 5-amino-4-isobutyl-1H-benzo[d]imidazole-1-carboxylate (4, 3.6 g, 12.45 mmol) in acetonitrile at 0°C were added dropwise aqueous 6 M hydrochloric acid (5 mL) and a solution of sodium nitrite (1.11 g, 16.19 mmol) in water (2 mL). This reaction mixture was stirred at room temperature for 45 min. In a separate round-bottomed flask, a solution of copper bromide (2.67 g,

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18.68 mmol) in 47% aqueous hydrobromic acid (7.5 mL) was prepared and heated to 70° C. The previous diazonium reaction mixture was added dropwise to this solution at 70° C. The resulting mixture was stirred for 1 h. Next, the mixture was basified with saturated sodium bicarbonate to pH 8 and extracted with ethyl acetate. The organic layer was washed with brine solution, dried over anhydrous sodium sulfate, filtered, and concentrated. The crude product was purified by CombiFlash (40 g, RediSep column) using 0-5% methanol in dichloromethane as eluent. The desired fractions were concentrated under reduced pressure to afford 5-bromo-4-isobutyl-1H-benzo[d]imidazole (5) as a green solid. Yield: 2.5 g, 80%; MS (ESI) m/z 255.06 [M+1]⁺.

Synthesis of methyl 4-isobutyl-1H-benzo[d]imidazole-5-carboxylate (6)

To a solution of 5-bromo-4-isobutyl-1H-benzo[d]imidazole (5, 1.50 g, 5.95 mmol) in methanol (30 mL) was added triethylamine (1.6 mL, 11.90 mmol). This reaction mixture was degassed with argon gas for 10 minutes. Then, [1,1'-bis(diphenylphosphino)ferrocene]palladium(II) dichloride.dichloromethane (1.45 g, 1.78 mmol) was added and the reaction mixture was charged with carbon monoxide gas at 100 psi and stirred in a parr vessel at 90° C. for 20 h. After completion of the reaction, the reaction mixture was filtered with celite and washed with methanol. The filtrate was concentrated to dryness under reduced pressure and the crude product was purified by CombiFlash (40 g, RediSep column) using 0-5% methanol in dichloromethane as eluent. The desired fractions were concentrated under reduced pressure to afford methyl 4-isobutyl-1H-benzo[d]imidazole-5-carboxylate (6) as a brown solid. Yield: 1.32 g, 95%; MS (ESI) m/z 233.21 [M+1]⁺.

Synthesis of 4-isobutyl-1H-benzo[d]imidazole-5-carboxylic acid (7)

To a solution of methyl 4-isobutyl-1H-benzo[d]imidazole-5-carboxylate (6, 1.5 g, 6.46 mmol) in tetrahydrofuran: methanol:water (1:1:1, 24 mL) at room temperature was added sodium hydroxide (0.62 g, 25.86 mmol). This reaction mixture was heated at 70° C. for 3 h. Then, the mixture was concentrated to dryness under reduced pressure to afford 4-isobutyl-1H-benzo[d]imidazole-5-carboxylic acid (7) as an off-white solid. Yield: 2.10 g, (crude); MS (ESI) m/z 219.16 [M+1]⁺.

Synthesis of 4-isobutyl-N,N-dimethyl-1H-benzo[d]imidazole-5-carboxamide (8)

To a solution of 4-isobutyl-1H-benzo[d]imidazole-5-carboxylic acid (7, 2.1 g, 9.63 mmol) in N,N-dimethylformamide (20 mL) at 0° C., dimethylamine hydrochloride (7a, 1.96 g, 24.08 mmol) and N,N-diisopropylethylamine (4.2 mL, 24.08 mmol) were added. Then, 1-propanephosphonic anhydride solution (50% in ethyl acetate) (4.60 mL, 14.44 mmol) was added to the reaction mixture which stirred at room temperature for 16 h. After completion of the reaction, the mixture was poured into ice water and extracted with ethyl acetate. The organic layer was washed with brine solution, dried over anhydrous sodium sulfate, filtered, and concentrated to dryness under reduced pressure. The crude product was purified by CombiFlash (40 g, RediSep column) using 0-10% methanol in dichloromethane as eluent. The desired fractions were concentrated under reduced pressure

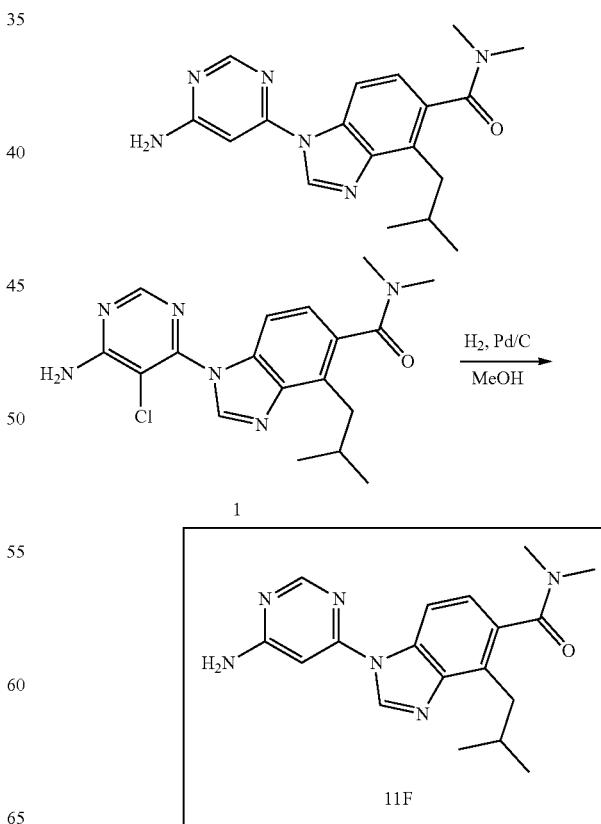
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to afford 4-isobutyl-N,N-dimethyl-1H-benzo[d]imidazole-5-carboxamide (8) as a brown solid. Yield: 0.60 g, 25%; MS (ESI) m/z 246.24 [M+1]⁺.

Synthesis of 1-(6-amino-5-chloropyrimidin-4-yl)-4-isobutyl-N,N-dimethyl-1H-benzo[d]imidazole-5-carboxamide (Cpd. No. 10F)

To a solution of 4-isobutyl-N,N-dimethyl-1H-benzo[d]imidazole-5-carboxamide (8, 0.6 g, 2.44 mmol) in N,N-dimethylformamide (5 mL), sodium hydride (60%, 0.12 g, 2.93 mmol) was added portion-wise at room temperature. This reaction mixture was stirred for 20 minutes. Then, 5,6-dichloropyrimidin-4-amine (8a, 0.44 g, 2.69 mmol) was added and the reaction mixture was heated at 110° C. for 16 h. After this time, the mixture was poured into ice-cold water and extracted with 10% methanol in dichloromethane. The organic layer was washed with brine solution, dried over anhydrous sodium sulfate, filtered, and concentrated to dryness under reduced pressure. The crude product was purified by prep HPLC to afford 1-(6-amino-5-chloropyrimidin-4-yl)-4-isobutyl-N,N-dimethyl-1H-benzo[d]imidazole-5-carboxamide (Cpd. No. 10F) as an off-white solid. Yield: 0.043 g, 4.7%; MS (ESI) m/z 373.18 [M+1]⁺; ¹H NMR (400 MHz, DMSO-d₆) δ 8.67 (s, 1H), 8.41 (s, 1H), 8.06-7.61 (bs, 2H), 7.47 (d, J=8.32 Hz, 1H), 7.12 (d, J=8.32 Hz, 1H), 3.02 (s, 3H), 2.76 (s, 3H), 2.51 (s, 2H), 2.21-2.14 (m, 1H), 0.85 (d, J=6.52 Hz, 6H).

Example 11: 1-(6-aminopyrimidin-4-yl)-4-isobutyl-N,N-dimethyl-1H-benzo[d]imidazole-5-carboxamide (Cpd. No. 11F)

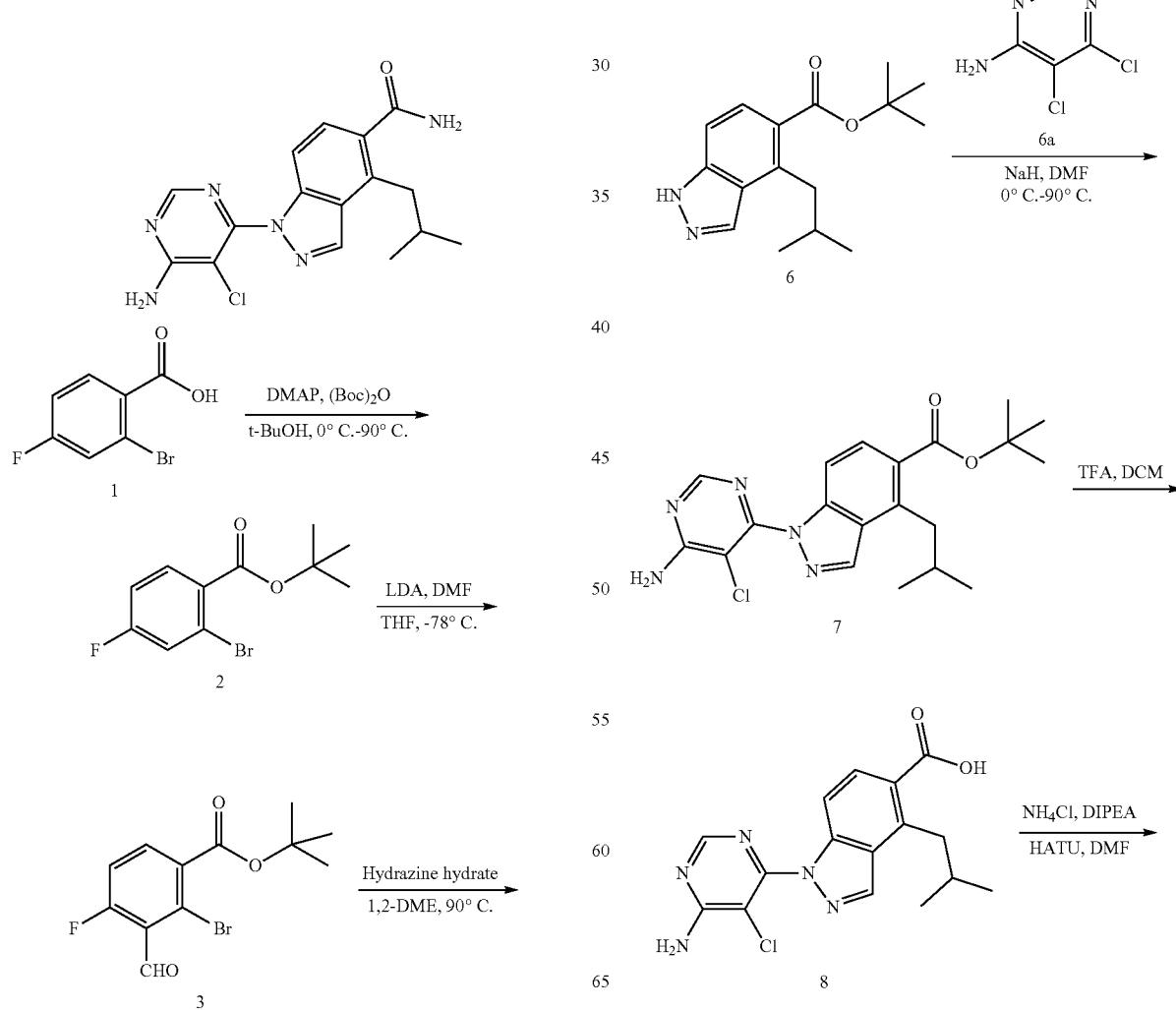


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Synthesis of 1-(6-aminopyrimidin-4-yl)-4-isobutyl-N,N-dimethyl-1H-benzo[d]imidazole-5-carboxamide (Cpd. No. 11F)

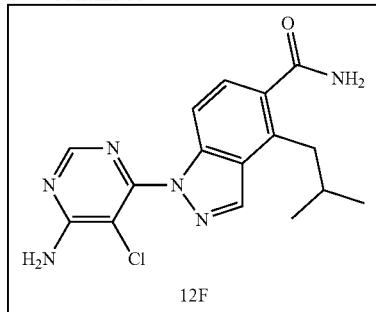
To a solution 1-(6-amino-5-chloropyrimidin-4-yl)-4-isobutyl-N,N-dimethyl-1H-benzo[d]imidazole-5-carboxamide (1, 0.05 g, 0.13 mmol) in methanol (5 mL), palladium on carbon (50%, 0.013 g, 0.065 mmol) was added at room temperature. This reaction mixture was stirred under hydrogen atmosphere (balloon) for 2 h. Then, the reaction mixture was filtered with celite and washed with methanol. The filtrate was concentrated to dryness under reduced pressure. The crude product was purified by prep HPLC to afford 1-(6-aminopyrimidin-4-yl)-4-isobutyl-N,N-dimethyl-1H-benzo[d]imidazole-5-carboxamide (Cpd. No. 11F) as a white solid. Yield: 0.015 g, 33%. MS (ESI) m/z 339.16 [M+1]⁺; ¹H NMR (400 MHz, DMSO-d₆) δ 8.86 (s, 1H), 8.43 (s, 1H), 8.03 (d, J=8.40 Hz, 1H), 7.22 (bs, 2H), 7.18 (d, J=8.4 Hz, 1H), 6.80 (s, 1H), 3.03 (s, 3H), 2.85 (bs, 2H), 2.76 (s, 3H), 2.16 (m, 1H), 0.84 (d, J=6.40 Hz, 6H).

Example 12: 1-(6-amino-5-chloropyrimidin-4-yl)-4-isobutyl-1H-indazole-5-carboxamide (Cpd. No. 12F)



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-continued



Synthesis of tert-butyl 2-bromo-4-fluorobenzoate (2)

To a stirred solution of 2-bromo-4-fluorobenzoic acid (1, 10.0 g, 45.6 mmol) in tert butanol (100 mL) at 0° C., N,N-dimethyl amino pyridine (5.57 g, 45.6 mmol) and boc anhydride (31.5 mL, 136.9 mmol) were added. This mixture was stirred at 90° C. for 2 h. Next, the reaction mixture was quenched with ice-cold water and extracted with ethyl acetate. The organic layer was washed with cold water, dried over anhydrous sodium sulfate, filtered, and concentrated to dryness under reduced pressure. The crude product was purified by silica gel (100-200 mesh) column chromatography using 5% ethyl acetate in hexanes as eluent. The desired fractions were concentrated under reduced pressure to afford tert-butyl 2-bromo-4-fluorobenzoate (2) as a colorless liquid. Yield: 10.0 g, 80%; MS (ESI) m/z 275.19[M+1]⁺.

Synthesis of tert-butyl 2-bromo-4-fluoro-3-formylbenzoate (3)

To a solution of tert-butyl 2-bromo-4-fluorobenzoate (2, 8.0 g, 29.2 mmol) in dry tetrahydrofuran (80 mL) at -78° C., lithium diisopropylamide (2.0 M in tetrahydrofuran, 29.2 mL, 58.4 mmol) was added dropwise. This reaction mixture was stirred for 1 h at same temperature. Then, N,N-dimethylformamide (4.5 mL, 58.4 mmol) was added and stirring was continued for 10 min. Next, the reaction was quenched with aqueous ammonium chloride solution and extracted with ethyl acetate. The organic layer was washed with brine, dried over anhydrous sodium sulfate, filtered, and concentrated to dryness under reduced pressure. The crude product was purified by silica gel (100-200 mesh) column chromatography using 30% ethyl acetate in hexanes as eluent. The desired fractions were concentrated under reduced pressure to afford tert-butyl 2-bromo-4-fluoro-3-formylbenzoate (3) as an off-white solid. Yield: 4.2 g, 48%; MS (ESI) m/z 302.91[M+1]⁺.

Synthesis of tert-butyl 4-bromo-1H-indazole-5-carboxylate (4)

To a solution of tert-butyl 2-bromo-4-fluoro-3-formylbenzoate (3, 3.75 g, 12.41 mmol) in 1,2-dimethoxyethane (22 mL) was added hydrazine hydrate (13.5 mL). The reaction mixture was sealed and heated at 90° C. for 2 h. Then, the reaction mixture was concentrated to dryness, diluted with water, and extracted with ethyl acetate. The organic layer was washed with brine solution, dried over anhydrous sodium sulfate, filtered, and concentrated to dryness under reduced pressure. The crude product was purified by Com-

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biflash (40 g, RediSep column) using 10-30% ethyl acetate in hexanes as eluent. The desired fractions were concentrated under reduced pressure to afford tert-butyl 4-bromo-1H-indazole-5-carboxylate (4) as an off-white solid. Yield: 2.0 g, 54.5%; MS (ESI) m/z 296.95[M+1]⁺.

Synthesis of tert-butyl 4-(2-methylprop-1-en-1-yl)-1H-indazole-5-carboxylate (5)

To a solution of tert-butyl 4-bromo-1H-indazole-5-carboxylate (4, 2.0 g, 6.75 mmol) in 1,4-dioxane (30.0 mL) and water (7.5 mL) was added cesium carbonate (4.39 g, 13.51 mmol) at room temperature. The reaction mixture was degassed with argon. Then, 4,4,5,5-tetramethyl-2-(2-methylprop-1-en-1-yl)-1,3,2-dioxaborolane (4a, 1.84 g, 10.13 mmol) and [1,1'-Bis(diphenylphosphino)ferrocene]palladium(II) dichloride (0.27 g, 0.33 mmol) were added. The reaction mixture was sealed and heated at 100° C. for 16 h. After this time, the reaction was quenched with water and extracted with ethyl acetate. The organic layer was washed with water and then saturated brine solution, dried over anhydrous sodium sulfate, filtered, and concentrated. The crude product was purified by silica gel (100-200 mesh) column chromatography using 50% ethyl acetate in hexanes as eluent. The desired fractions were concentrated under reduced pressure to afford tert-butyl 4-(2-methylprop-1-en-1-yl)-1H-indazole-5-carboxylate (5) as a white solid. Yield: 0.75 g, 41%; MS (ESI) m/z 273.09 [M+1]⁺.

Synthesis of tert-butyl 4-isobutyl-1H-indazole-5-carboxylate (6)

To a solution of tert-butyl 4-(2-methylprop-1-en-1-yl)-1H-indazole-5-carboxylate (5, 0.7 g, 2.57 mmol) in methanol (14 mL) was added 10% palladium on carbon (0.21 g). The reaction mixture was stirred under hydrogen atmosphere (balloon) for 16 h. After this time, the reaction mixture was filtered with celite. The filtrate was concentrated to dryness under reduced pressure to afford tert-butyl 4-isobutyl-1H-indazole-5-carboxylate (6) (crude) as a white solid. This crude product was used for next step without further purification. Yield: 0.70 g; MS (ESI) m/z 275.11[M+1]⁺.

Synthesis of tert-butyl 1-(6-amino-5-chloropyrimidin-4-yl)-4-isobutyl-1H-indazole-5-carboxylate (7)

To a solution of tert-butyl 4-isobutyl-1H-indazole-5-carboxylate (6, 0.25 g, crude, 0.91 mmol) in N,N-dimethylformamide (5.0 mL) was added sodium hydride (0.11 g, 2.73 mmol) at 0° C. This reaction mixture was stirred at same temperature for 1 h and then 5,6-dichloropyrimidin-4-amine (6a, 0.3 g, 1.82 mmol) was added. The reaction mixture was heated at 90° C. for 16 h. After this time, the reaction mixture was quenched with water and extracted with ethyl acetate. The organic layer was washed with water and then saturated brine solution, dried over anhydrous sodium sulfate, filtered, and concentrated. The crude product was purified by silica gel (100-200 mesh) column chromatography using 50% ethyl acetate in hexanes as eluent. The desired fractions were concentrated under reduced pressure to afford tert-butyl 1-(6-amino-5-chloropyrimidin-4-yl)-4-isobutyl-1H-indazole-5-carboxylate (7) as a white solid. Yield: 0.22 g, 60%; MS (ESI) m/z 402.17 [M+1]⁺.

Synthesis of 1-(6-amino-5-chloropyrimidin-4-yl)-4-isobutyl-1H-indazole-5-carboxylic acid (8)

To a solution of tert-butyl 1-(6-amino-5-chloropyrimidin-4-yl)-4-isobutyl-1H-indazole-5-carboxylate (7, 0.22 g, 0.55

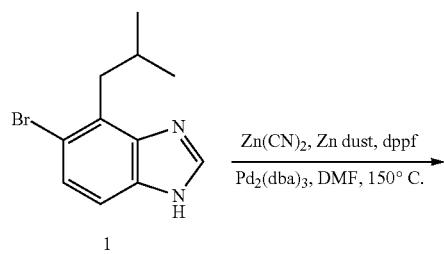
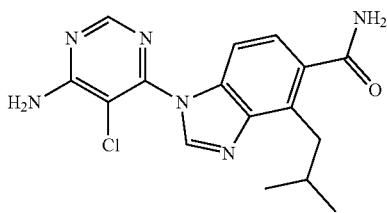
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mmol) in dichloromethane (4.4 mL) was added trifluoroacetic acid (2.2 mL) at room temperature. This mixture was stirred for 6 h. After this time, the reaction mixture was concentrated to dryness to afford 1-(6-amino-5-chloropyrimidin-4-yl)-4-isobutyl-1H-indazole-5-carboxylic acid (8) 5 as a white solid. Yield: 0.18 g; MS (ESI) m/z 346.10 [M+1]⁺.

Synthesis of 1-(6-amino-5-chloropyrimidin-4-yl)-4-isobutyl-1H-indazole-5-carboxamide (Cpd. No. 10 12F)

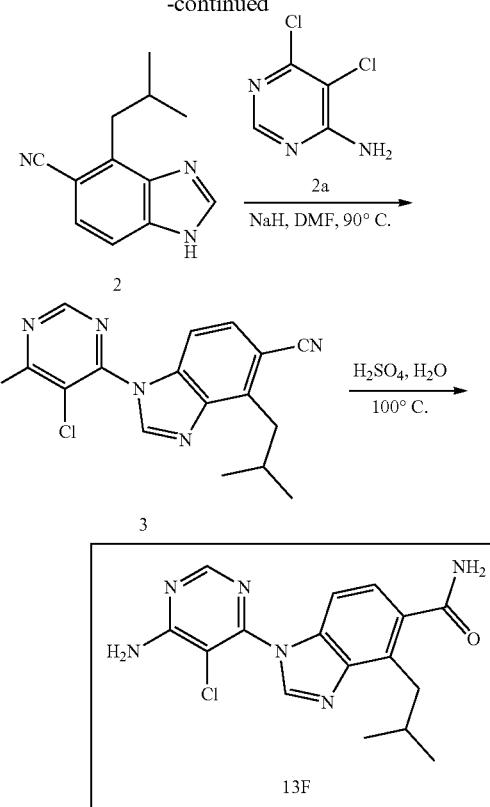
To a solution of 1-(6-amino-5-chloropyrimidin-4-yl)-4-isobutyl-1H-indazole-5-carboxylic acid (8, 0.15 g, 0.43 mmol) and ammonium chloride (0.12 g, 2.17 mmol) in N,N-dimethylformamide (5.0 mL) were added N,N-diisopropylethylamine (0.8 mL, 4.34 mmol) and (1-[Bis(dimethylamino)methylene]-1H-1,2,3-triazolo[4,5-b]pyridinium 15 3-oxid hexafluorophosphate (0.25 g, 0.63 mmol) at room temperature. This reaction mixture was stirred at room temperature for 16 h. After completion of the reaction, the reaction mixture was diluted with water and extracted with ethyl acetate. The organic layer was washed with ice-cold water and then saturated brine solution, dried over anhydrous sodium sulfate, filtered, and concentrated. The crude product was purified by silica gel (100-200 mesh) column chromatography using 70% ethyl acetate in hexane as eluent. The desired fractions were concentrated under reduced pressure to afford 1-(6-amino-5-chloropyrimidin-4-yl)-4-isobutyl-1H-indazole-5-carboxamide (Cpd. No. 12F) as a white solid. Yield: 0.070 g, 46.6%; MS (ESI) m/z 345.09 [M+1]⁺; ¹H NMR (400 MHz, DMSO-d₆) δ 8.61 (s, 1H), 8.31 (s, 1H), 7.96 (bs, 1H), 7.77 (bs, 1H), 7.72 (d, J=8.6 Hz, 1H), 7.59 (bs, 1H), 7.49 (d, J=8.6 Hz, 1H), 7.37 (bs, 1H), 3.08 (d, J=7.2 Hz, 2H), 2.04-1.97 (m, 1H), 0.89 (d, J=6.5 Hz, 6H).

Example 13: 1-(6-amino-5-chloropyrimidin-4-yl)-4-isobutyl-1H-benzo[d]imidazole-5-carboxamide (Cpd. No. 13F)



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-continued



Synthesis of 4-isobutyl-1H-benzo[d]imidazole-5-carbonitrile (2)

To a solution of 5-bromo-4-isobutyl-1H-benzo[d]imidazole (1, 0.45 g, 1.77 mmol) in N,N-dimethylformamide (10 40 mL) were added zinc cyanide (1.03 g, 8.88 mmol), Zn dust (0.23 g, 3.54 mmol). The reaction mixture was degassed with argon gas for 10 minutes. 1,1'-bis(diphenylphosphanyl) ferrocene (0.094 g, 0.17 mmol) and Tris(dibenzylideneacetone)dipalladium (0.155 g, 0.17 mmol) were added to the 45 reaction mixture. The mixture was heated to 150°C for 5 h. After completion of the reaction, the reaction was poured in to ice cold water and extracted with ethyl acetate. The organic layer was washed with brine solution, dried over anhydrous sodium sulfate, filtered and, concentrated to 50 dryness under reduced pressure. The crude product was purified by Combiflash (12 g, RediSep column) using 0-30% ethyl acetate in hexanes as eluent. The desired fractions were concentrated under reduced pressure to afford 4-isobutyl-1H-benzo[d]imidazole-5-carbonitrile (2) as light brown 55 solid. Yield: 0.26 g, 74%; MS (ESI) m/z 198.24 [M-1]⁻.

Synthesis of 1-(6-amino-5-chloropyrimidin-4-yl)-4-isobutyl-1H-benzo[d]imidazole-5-carbonitrile (3)

60 To a solution of 4-isobutyl-1H-benzo[d]imidazole-5-carbonitrile (2, 0.26 g, 1.30 mmol) in N,N-dimethylformamide (5.0 mL) was added (60% paraffin oil) sodium hydride (0.062 g, 1.56 mmol) at 0°C. The reaction mixture was stirred at same temperature for 1 h. 5,6-dichloropyrimidin-65 4-amine (2a, 0.23 g, 1.43 mmol) was added to the mixture. The reaction mixture was heated at 90°C for 16 h. After completion of the reaction, the reaction mixture was

quenched with water and extracted with ethyl acetate. The organic layer was washed with water, saturated brine solution, dried over anhydrous sodium sulphate, filtered and concentrated. The crude product was purified by column chromatography using silica gel (100-200 mesh) and 0-50% ethyl acetate in hexanes as eluent. The desired fractions were concentrated under reduced pressure to afford 1-(6-amino-5-chloropyrimidin-4-yl)-4-isobutyl-1H-benzo[d]imidazole-5-carbonitrile (3) as brown solid. Yield: 0.155 g, 37%; MS (ESI) m/z 327.26 [M+1]⁺.

Synthesis of 1-(6-amino-5-chloropyrimidin-4-yl)-4-isobutyl-1H-benzo[d]imidazole-5-carboxamide (Cpd. No. 13F)

A solution of 1-(6-amino-5-chloropyrimidin-4-yl)-4-isobutyl-1H-benzo[d]imidazole-5-carbonitrile (3, 0.12 g, 0.37 mmol) in sulphuric acid (1.2 mL) and water (0.1 mL) was heated at 100° C. for 16 h. After completion of the reaction, the reaction mixture was poured on to mixture of ice and sodium bicarbonate and extracted with ethyl acetate. The organic layer was washed with brine solution, dried over anhydrous sodium sulfate, filtered and concentrated to dryness under reduced pressure. The crude product was purified by CombiFlash (4 g, RediSep column) using 2-5% methanol dichloromethane as eluent. The desired fractions were concentrated under reduced pressure to afford 1-(6-amino-5-chloropyrimidin-4-yl)-4-isobutyl-1H-benzo[d]imidazole-5-carboxamide (Cpd. No. 13F) as white solid. Yield: 0.017 g, 13.3%; MS (ESI) m/z 345.13 [M+1]⁺; ¹H NMR (400 MHz, DMSO-d₆) δ 8.64 (s, 1H), 8.41 (s, 1H), 8.02 (bs, 1H), 7.71 (bs, 1H), 7.59 (bs 1H), 7.42 (d, J=8.36 Hz, 1H), 7.35 (d, J=8.36 Hz, 1H), 7.30 (bs, 1H), 3.15 (d, J=7.2 Hz, 2H), 2.16-2.09 (m, 1H), 0.87 (d, J=6.6 Hz, 6H).

MNK Biochemical Enzymatic Assay

Compounds are screened for MNK inhibition using the ADP-Glo kinase assay kit (Promega, catalogue No. V9101). All kinase reactions are performed in Reaction Buffer E (15 mM HEPES pH7.4, 20 mM NaCl, 1 mM EGTA, 10 mM MgCl₂, 0.1 mg/ml BGG, and 0.02% Tween-20). Final MNK1 reactions contained 10 nM recombinant MNK1 (Life Technologies, PR9138A), 100 μM MNK substrate peptide Ac-TATKSGSTTKNR-NH₂ (American Peptide Company), 300 μM ATP, and varying concentrations of the inhibitory compound of interest. Final MNK2 reactions contained 3 nM recombinant MNK2 (Life Technologies, PV5607), 50 μM MNK substrate peptide Ac-TATKSGSTTKNR-NH₂ (American Peptide Company), 10 μM ATP, and varying concentrations of the inhibitory compound of interest. Final DMSO concentration in each reaction is 1%.

Kinase reactions are carried out in 96-well half-area white flat-bottom polystyrene plates in a final volume of 25 al. MNK1/2 enzymes are pre-incubated with compound and peptide substrate for 5 minutes prior to the addition of ATP. After the addition of ATP, kinase reactions are incubated at room temperature for 40 minutes. Reactions are subsequently stopped by the addition of 25 al of ADP-Glo Reagent and incubating for an additional 40 minutes. The final luminescent signal used for kinase activity readout is produced by the addition of 45 al of Kinase Detection Reagent (ADP-Glo kit, Promega) and incubating for 40 minutes. The luminescent signal is detected using a Victor 2 multilabel counter (Perkin Elmer) and the concentration of compound necessary to achieve inhibition of enzyme activity by 50% (IC₅₀) is calculated using signals from an 8-point compound dilution series.

The results of these assays are set forth in Table 1 below. To this end, IC₅₀ values of less than 1 μM are labeled as “++”, from 1 to 10 μM are labeled as “++”, and from 10 to 100 μM are labeled as “+”.

TABLE 1

MNK Biochemical Enzymatic Assay (IC ₅₀)		
Structure	Compound	Potency (μM)
	12F	++
	10F	++
	11F	++
	13F	++
	8F	+

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10. The compound according to claim 1, or a stereoisomer, a tautomer or a pharmaceutically acceptable salt thereof, wherein R⁷ is —H, halogen or —(C₁-C₈)alkyl.

11. The compound according to claim 1, or a stereoisomer, a tautomer or a pharmaceutically acceptable salt thereof, wherein R⁹ and R¹⁰ are —H.

12. The compound according to claim 1, or a stereoisomer, a tautomer or a pharmaceutically acceptable salt thereof, wherein R¹¹ and R¹² are independently selected from the group consisting of —(C₁-C₈)alkyl, —(C₁-C₈)haloalkyl, heterocyclyl and cycloalkyl.

13. The compound according to claim 1, or a stereoisomer, a tautomer or a pharmaceutically acceptable salt thereof, wherein R⁸ and R¹³ are —H or —(C₁-C₈)alkyl.

14. The compound according to claim 1, or a stereoisomer, a tautomer or a pharmaceutically acceptable salt thereof, selected from

(3-(6-aminopyrimidin-4-yl)-5-chloro-1-methyl-7-(1-methylpiperidin-3-yl)-1H-indol-6-yl)(azetidin-1-yl) methanone,

(3-(6-aminopyrimidin-4-yl)-5-chloro-1-methyl-7-(1-methylpiperidin-3-yl)-1H-indazol-6-yl)(azetidin-1-yl) methanone,

(3-(6-aminopyrimidin-4-yl)-5-chloro-1-methyl-7-(1-methylpiperidin-3-yl)-1H-pyrrolo[3,2-b]pyridin-6-yl)(azetidin-1-yl) methanone,

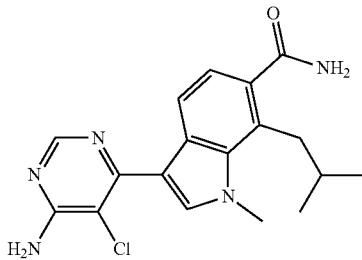
(3-(6-aminopyrimidin-4-yl)-5-chloro-1-methyl-7-(1-methylpiperidin-3-yl)-1H-pyrazolo[4,3-b]pyridin-6-yl)(azetidin-1-yl) methanone, and

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3-(6-amino-5-chloropyrimidin-4-yl)-7-isobutyl-1-methyl-1H-indole-6-carboxamide.

15. A pharmaceutical composition comprising (i) a therapeutically effective amount of at least one compound according to claim 1 or a stereoisomer, a tautomer or a pharmaceutically acceptable salt thereof; (ii) in combination with a pharmaceutically acceptable carrier, diluent or excipient.

16. A compound having the structure:



or a stereoisomer, tautomer, or a pharmaceutically acceptable salt thereof.

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